DOCUMENT RESUME

ED 308 083 SE 050 689

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TITLE The Use of the Fennema-Sherman Mathematics Anxiety and Confidence Scales as Predictors of Success among "Business Calculus Students" and "Fundamental Concepts of Mathematics" Students at the College Level.

PUB DATE 88

NOTE 162p.; Master's Thesis, Salisbury Sate College.

PUB TYPE Dissertations/Theses - Master Theses (042) -- Reports - Research/Technical (143) -- Tests/Evaluation Instruments (160)

EDRS PRICE MF01/PC07 Plus Postage.

DESCRIPTORS Attitude Measures; *College Mathematics; *College Students; Cultural Influences; Higher Education; Learning Problems; *Mathematics Achievement; *Mathematics Anxiety; Prediction; *Self Concept; *Student Attitudes; Undergraduate Study

ABSTRACT

In an attempt to explore the prevalence, intensity and effects of mathematics anxiety at Salisbury State College (Maryland) approximately 350 student volunteers from two diverse introductory mathematics courses participated in this survey. The Fennema-Sherman Mathematics Anxiety and Confidence Scales and a portion of the Test Anxiety Profile were administered. Final course grades were analyzed and compared with the anxiety profiles established earlier. The results indicated that mathematics anxiety did exist among the survey population but the use of the Fennema-Sherman Mathematics Anxiety and Confidence Scales was not as significant an indicator of success as were scores on the Scholastic Aptitude Test in Mathematics (SAT-MATH) and the institutionally-designed mathematics diagnostic instrument. The age and sex of a subject did not appear to be related to the incidence or intensity of mathematics anxiety, and a subject's hiatus from mathematics courses produced only a marginal significance. Included are 69 references, 21 tables, and 7 figures. Appendices include the Mathematics Anxiety Survey and the Mathematical Science Department Diagnostic Test. (Author/DC)

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THE USE OF THE FENNEMA-SHERMAN MATHEMATICS ANXIETY AND CONFIDENCE SCALES AS PREDICTORS OF SUCCESS AMONG "BUSINESS CALCULUS STUDENTS" AND "FUNDAMENTAL CONCEPTS OF MATHEMATICS" STUDENTS AT THE COLLEGE LEVEL

by

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B.S., University of Maryland, College Park, 1968

Abstract of Thesis

Submitted in partial fulfillment of the requirement for the
degree of Master of Education in Mathematics Education
Salisbury State College
Salisbury, Maryland
1988

Approved for the Graduate Faculty

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Research Project Director

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Accepted by the faculty of the Mathematical Sciences Department, School of Science, and the faculty of the School of Education and Professional Studies, Salisbury State College, in partial fulfillment of the requirement for the Master of Education in Mathematics Education degree.

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ABSTRACT

In an attempt to explore the prevalence, intensity and effects of "mathematics anxiety" at Salisbury State College during the fall, 1987 semester, approximately three hundred fifty student volunteers from two diverse introductory mathematics courses participated in the survey. The subjects were drawn from all sections of two mathematics courses: Algebra with Calculus (MATH 150), and Fundamental Concepts in Mathematics (MATH 103). The Fennema-Sherman Mathematics Anxiety and Confidence Scales were administered in an effort to quantify the range of these specific attitudes among this group. Since most evaluations of mathematics performance occur in a testing milieu, a portion of the Test Anxiety Profile was also administered in an attempt to distinguish general test anxiety from mathematics anxiety. Students were also asked to provide biodata indicating their age, sex, the number of years of high school mathematics studied, and the number of years of elapsed time since the last formal study of mathematics was undertaken. The researcher was also provided with consent from the subjects to access their Scholastic Aptitude Test scores in mathematics (SAT-MATH). Additionally, some introductory mathematics courses require a placement exam to determine the appropriateness of student skill levels for the particular class in which the student was

enrolled. The Mathematical Sciences Departmental Diagnostic Test (MSDDT) was therefore administered to students in MATH 103 and MATH 150 classes, to provide additional data pertaining to mathematics performance.

All data were collected by means of student social security numbers and cross-classified. At the end of the semester, final course grades were analyzed and compared with the anxiety profile established earlier for each subject to determine the predictive validity of the Fennema-Sherman Mathematics Anxiety Scale. By means of multiple regression analyses, a predictive equation for mathematics achievement for these students was derived from the collected data.

The results of the research indicated that mathematics anxiety did exist among the survey population but the use of the Fennema-Sherman Mathematics Anxiety Scale was not as significant an indicator of success in these courses as were scores on the SAT-MATH and the institutionally-designed diagnostic instrument currently in use in MATH 150 classes. Confidence and anxiety towards mathematics emerged as attitudes lacking independence, while mathematics anxiety and general test anxiety were reported as discrete conditions. The age and sex of a subject did not appear to be related to the incidence or intensity of mathematics anxiety, and a subject's hiatus from mathematics courses produced only a marginal significance when compared to a mathematics anxiety score. It appears therefore that while mathematics anxiety does exist, the debilitative aspect of this condition was unable to be observed in this study. Since other measures appear more reliable, as a result of this research, the Fennema-Sherman Mathematics Anxiety Scale cannot be recommended as a predictor of achievement in introductory mathematics courses at the college level.

THE USE OF THE FENNEMA-SHERMAN MATHEMATICS ANXIETY AND CONFIDENCE SCALES AS PREDICTORS OF SUCCESS AMONG "BUSINESS CALCULUS" STUDENTS AND "FUNDAMENTAL CONCEPTS OF MATHEMATICS" STUDENTS AT THE COLLEGE LEVEL

by

Rosemary Pataky Heher

Submitted in partial fulfillment of the requirement for the degree of Master of Education in Mathematics Education

Salisbury State College
Salisbury, Maryland

1987

ACKNOWLEDGMENT

The writer is indebted to several individuals without whom this work would not have been possible. Mrs. Linda Abresch, secretary of the Mathematical Sciences Department, who without complaint, shared her office with vast stacks of paperwork which were required for surveying a population of this size. Dr. Carol Williamson who encouraged me to crystallize exactly which "angel on the head of a pin" would receive the focus of this research. Dr. Janice French unselfishly provided time and much of the technical support for the statistical treatments and when an accident fractured the researcher's finger, Dr. French sympathetically added her typing skills. From the start, Dr. Homer Austin shared an interest in the subject of mathematics anxiety and willingly offered both input on design during the months the project's director was on sabbatical as well as advice on statistical applications. Lastly, acknowledgment is accorded Dr. Donald Cathcart, former chairman of the Mathematical Sciences Department, research director, mentor, and most importantly, friend, who unceasingly provided encouragement, direction and insight not only for this project, but for this graduate student's professional aspirations.

R.P.H.

DEDICATION

This research is dedicated to my husband, Dr. Joseph Heher, and my daughter, Ashley, who never stopped believing in me and my desire to become a mathematics instructor. Thank you both for the years you supported my effort, enduring diminished time, attention and energy from me. Your sacrifices provided the means for me not only to maintain a focus on the goal I set for myself, but on its level of accomplishment as well.

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CHAPTER I

INTRODUCTION

America has long been known as the "melting pot". As a nation, it is an amalgam of diverse ethnic, racial, religious, cultural and social populations. This diversity at the college level however appears to be a more recent phenomenon; not long ago college was the domain of a privileged class of students whose academic talent and affluence afforded them the ability to defer earning a living until the attainment of at least the baccalaureate degree.

At the turn of the century, the average American attended school for about eight years; graduation from "grammar school" marked not only the end of childhood and one's entrance into the labor market but for many, the end of all formal learning. By World War II, graduation from a four-year high school was considered the *sine qua non* of modern life (Hillway, 1964). Today, with societal influences such as:

(a) the post-war baby boom which has supplied unprecedented numbers of children to be educated,

(b) an insistence on a higher standard of living than realized by one's parents,

(c) an increased awareness of the value of a college education,

(d) the feminist movement which has redefined the role of women,

(e) the civil rights movement,

(f) and related college admission policies which have made the phrase "college material" seem archaic,

an unprecedented number of students are presenting themselves on college doorsteps seeking undergraduate and graduate degrees from our nation's institutes of higher education. The magnitude of this situation on college admission officials becomes more apparent when one realizes that by the year 1990, almost one-half the nation's population will have attended college (Crary, Pfahl, & Donaldson, 1980).

Numerous problems have beset college administrators in response to the diversity of populations making an appearance on today's campuses. At some institutions, open, non-selective admission policies allow any high school graduate, regardless of previous high school academic performance to become matriculated. The marginally prepared student often finds it necessary to be provided with special support services in the basic skills of reading, writing and mathematics, in order to gain the proficiency necessary for successful performance at the post-secondary level. Discrepancies in grading standards among high school teachers, and variations in the quality of programs and standards among many high schools may camouflage actual levels of academic accomplishment and make comparisons of students' pre-college preparation a difficult task for college admission officials.

Over the past two decades, as high school graduation requirements appear to have undergone changes, the growing practice of offering a wide array of high-interest elective courses has taken place at the expense of mastery in some fundamental curriculum areas, such as the mathematics sequence of algebra, geometry, trigonometry and pre-calculus. A 1980 report issued by the American Association for the Advancement of Science found only one-third of high schools required more than one year of mathematics or science for graduation (Smith, 1981). Such minimal exposure to mathematics or science results in inadequate preparation for the rigors of college-level studies.

Another area which warrants special consideration by college administrators is the so-called group of non-traditional students who may be older, with family and/or occupational commitments in addition to academic responsibilities. The _Carnegie Report of Policy Studies in Higher Education_ has speculated that:

> "...by the year 2000, post-secondary institutions will enroll more women than men, as many people over 21 as under and nearly as many part-timers as full timers. The traditional college-bound group of 18-24 year olds will

> have declined by 23%. This impact will be offset by increases in particular by students 25 or older, by women, and by members of minorities" (Smith, 1981, p.3).

For the older, returning student at both the graduate and undergraduate level, many years may have elapsed since the last exposure to formalized study in an academic setting. While previous successful performance might have existed, the inability to use learned skills particularly in areas such as foreign language, science and mathematics, may result in atrophy of these previously acquired skills (Tobias & Weissbrod, 1980). When prior educational achievement was at the marginal level, and the elapsed time between academic courses lengthy, self-doubts and performance anxieties may substitute for determination and priority-setting behaviors, possibly resulting in a diminished academic experience (Betz, 1978).

While SAT and ACT scores, high school grade point averages and class standings may have certain predictive validities, many institutions and/or academic departments have found it necessary to require in-house diagnostic or placement examinations to determine specific competencies in certain subject areas, attempting to assure correct placement and homogeneity of skills within the class. However, a study of performance attributes reveals that in addition to cognitive skills, affective variables such as emotionality or anxiety are often coincidental (Morris, Kellaway & Smith, 1978) and yet may be too easily overlooked. Placement or diagnostic instruments which are solely skills-based, may fail to recognize attitudinal effects, such as anxiety, on a student's academic achievement. Mathematical studies seem to be particularly vulnerable to this phenomenon. Whipkey researched the relationship between mathematical attitudes and achievement in mathematics and strengthened the position that "a mathematical attitude does have a relationship with an associated behavioral disposition, which is the determinant, or consequence of the attitude" (1969; p.3808A).

The existence, prevalence and intensity of this attitudinal construct, described as confidence towards mathematics at one extreme and anxiety towards mathematics at the opposite (herein termed the anxiety/confidence complex) has not been widely researched (Lazarus, 1974). While conflicting data have surfaced among college populations, overall research conclusions indicate confidence towards mathematics correlates positively with mathematics performance, while high anxiety towards mathematics demonstrates a negative correlational coefficient with respect to achievement in math. Tobias and Weissbrod noted "...in professional circles, mathematics anxiety or mathophobia is well recognized as contributing to underachievement in math" (1980, p.63). This phenomenon has been observed from grade school through college (Clute, 1984) and appears unrelated to general anxiety or to overall intelligence factors (Digilio, 1987; Dreger & Aiken,1957). Butler & Austin-Martin report that mathematics anxiety appears to be a construct not easily defined (1981), because of the diverse and complex discipline which characterizes mathematics (Rounds & Hendel, 1980a), and in fact may vary sufficiently with each afflicted individual. Although a moderate level of tension, termed facilitative anxiety can be associated with better task performance (Alpert & Haber cited in Callahan, 1971), when these facilitative anxieties deteriorate into debilitative anxieties, negatively affecting achievement (Crosswhite, 1972), an emotionally-based, non-intellective, concept-specific learning problem may surface (Kogelman & Warren, 1978). This learning problem may masquerade as an ability problem when, in fact, the actual disability is rooted in attitude not aptitude. It is precisely this psychological dimension of attitude which aptitude-based diagnostic and placement tests in mathematics tend to overlook in determining competencies and placement and in predicting mathematical achievement. This affective variable, termed mathematics anxiety, and its relationship to performance were the subject of interest to this researcher and served as the overall motivation for this study.

Statement of the Problem

The overall objective of this research effort was to evaluate the predictive value of an instrument in which the construct "mathematics anxiety" was measured in relationship to student success in two introductory college mathematics courses at Salisbury State College. Presently skills-based diagnostic and placement tests are used to determine the appropriate level of the students' preparedness for introductory mathematics courses. Yet in spite of these tests, attrition rates are high and final grades often low for many of these students. Therefore, a need for researching a dimension beyond those involved with cognitive abilities seemed to be in order.

The specific objectives for this research effort were the following:

(a) To document the prevalence and intensity of the constructs, "mathematics anxiety" and "mathematics confidence", existing in two groups: students required to study business calculus, and prospective elementary education teachers studying fundamental concepts of mathematics.

(b) To investigate the relationship of mathematics anxiety to confidence towards mathematics.

(c) To differentiate the occurrence of general test anxiety from mathematics anxiety among this population.

(d) To ascertain whether skills-based data such as SAT-MATH scores, and non-skills based data such as a student's sex and the number of years a student studied high school mathematics actually demonstrate a relationship to the anxiety index among the group of college students surveyed in this research effort.

(e) To ascertain whether the Mathematical Sciences Departmental Diagnostic Test, now presently required in some introductory courses, is as predictive as the anxiety scale in measurement of student achievement in MATH 150 at the end of the fall '87 semester.

(f) To examine the relationship of mathematics anxiety to achievement in these introductory courses in mathematics.

(g) To establish the relative value as predictors of achievement in MATH 150 and MATH 103 of the anxiety scale, SAT-MATH scores, the Mathematical Sciences Diagnostic Test, the number of years of high school mathematics and the number of years elapsed since high school mathematics was formally studied.

Value of the Research

Conflicting research data exist regarding the relationship between the construct, mathematics anxiety, and student performance in mathematics classes. Some researchers present no significant correlation (Brown, R.M., 1979; Resnick, Viehe and Segal, 1982; Szetel cited in Morris, Kellaway and Smith, 1978), but suggest limitations inherent in their research, such as the nature of the institution, the population in general and the sample in particular. Other researchers cite small but significant relationships between anxiety and performance (Dew, Galassi and Galassi, 1984), while others find high correlational coefficients linking the prevalence and intensity of mathematics anxiety to student avoidance with respect to mathematics course-taking, and achievement in mathematics courses (Austin-Martin, 1980; Betz, 1978; Clute, 1984; Dreger and Aiken, 1957; Kogelman and Warren, 1978; Oetting and Deffenbacher, 1980).

With respect to the business calculus students, the Mathematical Sciences department has expressed concern over the high attrition rate and high rate of re-enrollment among many of the students taking this course. Since successful completion of this course is a requirement for admission into the business degree program, in a sense, the course becomes a critical filter determining not only the student's major but also his/her choice of a future career. This occurs despite the fact the students enrolled in these sections have previously demonstrated certain competencies by successfully passing the departmental diagnostic test. It would seem therefore, another dimension of performance with respect to this calculus course is influencing the students and in need of investigation. To date, no empirical assessment of the prevalence and intensity of math phobia among these students has taken place.

Nationwide, colleges of education are troubled that their students often demonstrate the lowest quartile in SAT scores among college populations (Fiske, 1987); also, the most academically talented students have been found to opt for careers outside the field of education (ibid.). Moreover, researchers have alluded to the fact that women, more than men, seem to be troubled by high mathematics anxiety scores (Betz, 1978; Brown, R.M., 1979; Crosswhite, 1972; Digilio, 1987; Fennema and Sherman, 1976; Hendel, 1977; Kogelman and Warren, 1978; Oetting and Deffenbacher, 1980). Since more women than men comprise the students of the School of Education at Salisbury State College, this information might prove useful in an assessment of the level of mathematics anxiety among this college population. Even more importantly, researchers cite grade school mathematics teachers as possible sources of inculcating mathematics anxiety among elementary age students (Hilton, 1980; Lazarus, 1974; Shodahl, 1985; Stodolsky, 1985). Since an aversion to mathematics has been documented by Fadon as early as the third grade (cited in Brown, R. M., 1979), and seems to be firmly established by sixth or seventh grade

(Crosswhite, 1972), the role of the elementary education teacher in engendering negative attitudes toward mathematics cannot be overlooked. If research indicates many elementary school teachers are uncomfortable teaching mathematics (Dutton, 1954), and if the preponderance of graduates of the School of Education are female, who statistically report higher mathematics anxiety scores than their male counterparts, the inclusion of this group in this research effort might provide important data relevant to the training of future teachers at Salisbury State College. To date, documentation of the existence of this phenomenon among this population at Salisbury State College has not taken place.

Lastly, of the many counseling services offered to students, several problem areas where counseling has proven to be of assistance are listed in the Salisbury State College catalog (p.32); among the description of services to help counteract performance anxieties related to test-taking, public speaking, recitals and athletics, the omission of mathematics anxiety as a "performance problem" is noteworthy. While the Counseling Center is attuned to the problem of mathematics anxiety (derived from private conversations with the Director, Counseling Center), by its omission from the academic catalog, students may be unaware that interventional therapy for math phobia is available to them. Therefore, an additional value of this research lies in providing empirical evidence for the possible prevalence, intensity and distribution of the construct called mathematics anxiety so if it is found to exist, then concept-specific interventional strategies can be more readily publicized to those students who might otherwise remain uninformed and at risk.

Limitations of the Research

By nature of the project undertaken, certain research limitations are inevitable and must be addressed. The affective variable, mathematics anxiety, is not only difficult to define, but involves problems of accurate measurement. Rounds and Hendel have argued many ambiguities of the mathematics anxiety construct are traceable to a lack of agreement on the conceptualization of mathematics anxiety (1980a); they state since mathematics is a complex discipline involving many kinds of related but diverse subject matter and skills, to assume a person feels the same toward each aspect of mathematics is unreasonable. The study of mathematics anxiety is additionally hampered by the use of psychometric instruments which attempt to measure the existence, prevalence and intensity of the construct. The validity of the instruments which measure mathematics anxiety, confidence towards mathematics and general test anxiety may be subject to challenge in a research effort. Since present instruments rely solely on pen-and-paper tests using self-reports by subjects, some loss of validity and diminished accuracy must be acknowledged.

The arbitrariness and ambiguity of evaluating "student success" in a course of study solely by use of a letter grade presents problems in educational research studies (Dreger & Aiken, 1957). While the Salisbury State College catalog defines levels of student achievement in terms of each letter grade (p. 46), the evaluation process can lend itself to certain subjectivities thus contributing to levels of inexactness which may permit some contamination of the research result.

While an attempt has been made to utilize all students in all sections of the cited introductory mathematics courses in an endeavor to increase generalizability to future populations in these classes, the concept of mathematics anxiety as a local phenomenon, as reported by Resnick, Viehe and Segal (1982), must be taken into consideration. Since this correlational study is of an institutional nature, generalizations to other colleges and universities must necessarily be limited. Resnick has stated the "prevalence (of mathematics anxiety) differs dramatically from one institution to another, limiting generalizations based on only one college sample" (1982, p.44). Therefore, the results of this study will be most pertinent to the student body at Salisbury State College.

The use of final grades for determination of "success" in a college class overlooks those particular students who have withdrawn prior to completion of the course. Tobias and Weissbrod report "...anxiety inhibits (mathematic) endeavors because in order to avoid the anxiety, the student will stop studying math" (1980, p. 65). While some students may exhibit valid reasons for withdrawal during the semester (schedule conflicts, health problems, employment or family conflicts, etc.), this researcher was unable to determine the rate of attrition due to math avoidance tendencies originating from math phobia among the group who were lost from the study.

Other possible limitations of this study include varying levels of effective teaching and/or learning which present the possibility of influencing final grades beyond that which might ordinarily have been predicted. The inexperience of this researcher in project design and in administering and interpreting the battery of tests which comprise some of the raw data essential to this research, the use of a single semester of data collection, the inclusion of only mathematics students in introductory courses, and the lack of student data such as class standing or SAT scores for all subjects in the study are additional factors which operate independently and in conjunction with one another to place certain restrictions on an accurate assessment of the problem under consideration.

Definitions of Terms

Since terms related to educational research lack the precision which exists in such areas of study as the pure sciences and mathematics, definition of some terms and refinement of some concepts become necessary in an effort to prevent misunderstanding and enhance the communicative process.

MATHEMATICS ANXIETY refers to "feelings of tension and anxiety that interfere with manipulation of numbers and the solving of mathematic problems in a wide variety of ordinary life and academic experiences" (Richardson & Suinn, 1980, p. 551). As it is used in this study, mathematics anxiety is a score which was measured on the Fennema-Sherman Mathematics Anxiety Scale (FSMAS). A low score on the FSMAS indicates high anxiety towards mathematics, while a high score on the FSMAS indicates lack of anxiety.

CONFIDENCE TOWARDS MATHEMATICS refers to the affective or emotional variable which represents the opposite dimension of anxiety. It is a positive attitude which encompasses a healthy self-esteem and connotes security with respect to one's ability to learn, perform and enjoy mathematics. As it is used in this study, confidence towards mathematics is a score which was measured on the Fennema-Sherman Mathematics Confidence Scale

(FSMCS). A low score on the FSMCS indicates lack of self confidence in the study of mathematics, while a high score on the FSMCS indicates a high degree of self confidence.

For purposes of this study, ACHIEVEMENT IN MATHEMATICS was determined by final course grades. Grades of "A", "B", "C" indicate a successful completion of the course and therefore, were categorized as indicators of achievement, while grades of "D", "F", and "W" (withdraw) indicate lack of successful completion of the course and were designated as indicators of lack of academic achievement.

Terms which are used specifically in this study, as it was conducted at Salisbury State College include: FUNDAMENTAL CONCEPTS IN MATHEMATICS, (MATH 103) is intended for prospective elementary school teachers. The properties of the number system are developed using set concepts as the basis for the development. Additional topics use algorithms, numeration systems and extensions of the natural number system and geometric application. This course does not satisfy the general education requirement. BUSINESS CALCULUS or ALGEBRA WITH CALCULUS, (MATH 150) refer to a course designed to review algebra with an introductory study of differentiation with emphasis on techniques of application to problems taken from business, management and other related fields (ibid., p. 40). Both courses cited are introductory college mathematics courses and carry three semester hours of credit.

THE MATHEMATICAL SCIENCES DEPARTMENTAL DIAGNOSTIC TEST (MSDDT) is a ten-item skills test first developed in 1977 by then faculty member, Dr. David Parker, and modified as a result of research conducted by Stephanie Shultz (1985) and administered to among others, all MATH 150 students on the first day of class. Designed to predict the probability for success based on demonstrated competencies, the test follows "a conventional pedagogical scheme with the first questions requiring only arithmetic skills, followed by algebraic expressions and ending with higher degree equations and expressions using two or more unknowns" (Shultz, 1985). Grading indicates the number of correct responses and students receiving scores of 0-5 are advised their probability for success will be poor and advised to drop the course, while those students scoring between 6-10 are believed to have the potential for successful achievement. Reliability and validity data were researched by the test's author and corroborated in an independent study by then graduate student, Stephanie Schultz, as the subject of a master's degree thesis.

GENERAL TEST ANXIETY is the amount of anxiety a student experiences under test-taking conditions. As it is used in this study, general test anxiety is a score which was measured on the Test Anxiety Profile (TAP). A low score on the TAP would indicate a high degree of general test anxiety, while a high score would indicate a general confidence under test-taking conditions.

HIGH SCHOOL PREPARATION LEVEL is the amount of academic mathematics studied prior to the college experience. Specifically, courses in introductory algebra, intermediate algebra (with or without trigonometry), formal geometry and calculus or pre-calculus are classified in this category and indicate preparedness. Courses such as business mathematics, general mathematics, consumer mathematics or pre-algebra are not considered "academic" mathematics and indicate lack of preparation. Scores were reported either as "less than 2 years", "less than 3 years", "less than 4 years", or "4 years".

HIATUS FROM FORMAL STUDIES OF MATHEMATICS, is the length of elapsed time since a student was last exposed to a formal study of mathematics as indicated by the definition of high school preparation in the above paragraph. Levels were reported as "less than 6 months", "1 year", "2 years", "3 years" or "greater than or equal to 4 years".

Finally, SAT-MATH SCORE is a standard score on the mathematics portion of the Scholastic Aptitude Test and an indicator of potential success in college studies. As reported by the Educational Testing Service of Princeton, New Jersey, the range of possible scores is between 200 - 800. In this study, student scores range from 220 - 700. Mean scores for this population were found to be 480 and for purposes of analysis, condensation of scores were at the following levels: "less than 450", "451-550", "551-800".

CHAPTER II

REVIEW OF RESEARCH AND RELATED LITERATURE

Attitudes Toward Mathematics

Attitudes are acquired through life experiences which have a pronounced affective component, not always clearly discernible. Needs, wishes, ideals, cultural influences and opportunities for experiences all intertwine in the development of an individual's unique set of attitudes (Blair, Jones, & Simpson, 1968). From the first awareness of having fingers and toes, to counting pennies and measuring with a ruler and then on to later experiences with calculators and computers, exposure to mathematical attitudes, both positive and negative, evolve within and without the classroom. Initially, most children in grade school report generally liking mathematics (Callahan, 1971). Boys and girls tend to function rather consistently through the elementary school years with girls actually exhibiting a slight margin in computational skills (Tobias, 1978). However, subtle changes begin to take place at about the sixth grade as large numbers of girls seemingly learn to dislike mathematics at about the same time boys appear to become more proficient at solving word problems (Dutton, 1954; Tobias, 1978). While girls are generally the first to exhibit deterioration of attitudes toward mathematics (Crosswhite, 1972), it has been hypothesized as children of both sexes progress through school, a significant decline in attitudes towards math occurs (Neale cited by Brown, R. M., 1979; Lazarus, 1974). Tobias corroborates this position by confirming although girls at an earlier age appeared to hold more negative attitudes towards mathematics than did boys, by the twelfth grade, a majority of all students had developed an aversion to mathematics which could not be generalized to other subject areas (Tobias, 1978).

While complex attitudes towards mathematics have been identified and measured by means of psychometric instruments (which will be described in the ensuing pages), as in so many aspects of educational and psychological research, a consensus of research data is often difficult to achieve. The actual existence of the singular construct, termed mathematics anxiety, has been challenged by some researchers (Resnick, Viehe and, Segal, 1982). Given the diverse and complex nature of mathematical studies, Rounds and Hendel challenge an accurate definition of mathematics anxiety, claiming it is not easily defined; they contend it is unreasonable to claim an individual would respond continually and with equal intensity to the varied aspects of quantitative studies (1980a). However, other researchers have little difficulty recognizing the condition and acknowledging the existence of the construct. In defining mathematics anxiety, the most prevalent definition appears to be provided by Richardson and Suinn. They state mathematics anxiety is "a kind of tension experienced by an individual which interferes with the manipulation of numbers or the solving of mathematical problems in ordinary life situations as well as in academic setting" (1980, p. 551). Appearing synonymously with the term mathematics anxiety, are the words math phobia and mathophobia, which involve "an irrational and impeditive dread of mathematics which, for a variety of reasons can develop into emotional and intellectual blocks, making further progress in math and closely related fields very difficult" (Lazarus, 1974, p.16). To avoid any hint of confusion, Lazarus further differentiates between the words mathophobia and dyscalculia, and their underlying significance (ibid.). The former is described as an emotionally-based, attitudinal problem which is unrelated to general intelligence (Digilio, 1987; Dreger & Aiken, 1957; Lazarus, 1974), while the latter is a cognitive problem involving an intellective inability to manipulate numbers.

Historical Development of Instrumentation to Measure Mathematics Anxiety

As an awareness of the existence of certain attitudes relating to the study of mathematics, and their effects on the learner and the process of learning increased, the need for psychometric instruments which differentiated general attitudes and general anxiety from those associated with mathematics became apparent. In 1954, Dutton developed the first scale specifically for researching attitudes toward the study of mathematics. Designed to measure one's enjoyment of mathematics, and to establish a chronology for attitudinal acquisition, the instrument was originally intended for use with prospective elementary school teachers (1954). However, subsequent studies have shown the scale can be readily implemented in assessment of attitudes in children as young as the third grade (Sandman, 1974). Of those pre-service teachers tested, 64% reported their attitudes towards mathematics were developed by about the sixth grade. Furthermore, and of some significance to this study, it was revealed some 39% of those prospective elementary teachers reported a lack of confidence in their abilities to perform arithmetic (Dutton, 1954; Sandman, 1974).

In 1957, Dreger and Aiken were credited with developing the Mathematics Attitude Scale which attempted to measure a range of student attitudes from enjoyment of mathematics to anxiety or fear with respect to numeration situations. Various versions of the test were devised to be used with students ranging from sixth grade through college.

Seven years later, Ryan conducted convergent validity research comparing the Dutton Attitude Scales and the Dreger-Aiken Mathematics Attitude Scales and found a correlation coefficient of .82, thus eliminating the possibility they measured two distinct constructs and lending support to the idea they measured nearly the same general attitude towards mathematics (Sandman, 1974).

By 1972, Richardson and Suinn had developed the Mathematics Anxiety Rating Scale (MARS). It investigated the existence and prevalence of a single negative attitude, namely mathematics anxiety, as a unidimensional construct. Attempts to establish construct validity for the MARS resulted in the emergence of not one homogeneous factor, but two dimensions to the anxiety associated with a study of mathematics, namely:

1. an anxiety pertaining to numerical manipulations and
2. mathematics test taking anxiety (Alexander & Cobbs, 1984; Rounds & Hendel, 1980a).

Rounds further researched the MARS and discovered the possibility of yet a third dimension, that of anxiety associated with mathematics skills evaluation which appeared to be operant within the mathematics anxiety construct (ibid.).

The Mathematics Attitude Inventory (MAI) was developed in 1973 by Sandman for use with junior high school ~~and high~~ school age students. The multidimensional inventory presumed six constructs associated with the development of attitudes toward mathematics:

1. mathematics anxiety,
2. perception of the mathematics teacher,
3. enjoyment of mathematics,
4. value of mathematics in society,

5. self confidence and
6. motivation in mathematics.

Unfortunately, little supportive research appears to have taken place regarding this inventory (Sandman, 1974; Frary & Ling, 1983). Perhaps this lack of research can be related in part to the National Science Foundation grant provided to Fennema and Sherman in 1976 which subsidized the development of the Fennema-Sherman Mathematics Attitudes Scales, a multidimensional instrument which purported to measure nine discrete dimensions of attitudes toward mathematics:

1. anxiety towards mathematics,
2. confidence towards mathematics,
3. effectance motivation (an attempt to assess the amount of enjoyment experienced in solving mathematical problems),
4. perception of success in mathematics,
5. perception of the usefulness of mathematics,
6. mathematics as a male domain,
7. perceptions of mother's attitudes towards one as a learner of mathematics
8. father's attitude towards one as a learner of mathematics,
9. and one's teachers' attitudes toward one as a learner of mathematics.

The scales were originally tested on high school students, to assess sex differences with respect to the constructs surveyed, but were easily adapted for use with undergraduate and graduate students at the college level. Research by the developers of the scale and subsequent studies have found the anxiety and confidence constructs compare very closely with a correlation coefficient reported at .89 (Fennema & Sherman, 1976; Wikoff & Buchalter, 1986). In actuality, it would appear that because anxiety and confidence share an inverse relationship with one another, this coefficient should more accurately be reported as -.89. Such research supports the hypothesis the two scales appear to measure the same construct, but at opposite extremes in their dimensionality (Fennema & Sherman, 1976; Wikoff & Buchalter, 1986), and in fact, the construct might more accurately be termed, the anxiety/confidence complex. It is perhaps the more encompassing scope of the Fennema-Sherman Mathematics Attitude Scale and its publication just three years subsequent to the Sandman Mathematics Attitude Index which accounts for the research attention which the Fennema-Sherman Mathematics Attitude Scale has received in recent years (Betz, 1978; Broadbooks, Elmore, Pederson & Bleyer, 1979; Brown, R. M., 1979; Butler & Austin-Martin, 1981; Crosswhite, 1972; Dew, Galassi & Galassi, 1984; Kincaid & Austin-Martin, 1981; Ripps, 1985; Rounds & Hendel, 1980a; Rounds & Hendel, 1980b; Wikoff & Buchalter, 1986).

Causes of Mathematics Anxiety:

The causes of mathematics anxiety are probably as varied as the number of individuals experiencing this phenomenon. While it would be beyond the scope of this research effort to catalog all the many and varied influences contributing to this condition, some of the more salient causes are included. Personality factors, educational influences, cultural and societal conditions and factors of cognitive development may be contributory by themselves and in combination with one another, possibly exacerbating the problem of mathematics anxiety with respect to prevalence, intensity, and distribution of under-achievement in mathematics among certain populations. Highlights of recent research in each of these areas are included:

1. Personality Influences:

The role of personality with respect to mathematics anxiety and its relationship to trait anxiety, remains an area of dispute with some contradictory evidence reported. Among a female college sampling, Llabre and Suarez noted only a 4% shared variance between mathematics anxiety and general anxiety; by contrast, a 24% variance was reported for the males sampled. Tobias reported the frequency of a personality profile in which both mathematics anxiety and general anxiety were coexistent (1975). But this characteristic was not uniformly supported in other research studies. Morris reported "...math anxiety and general anxiety do not go hand in hand. A math anxious individual may in general not be an anxious person at all, or vice versa" (cited in Berebitsky, 1981, p. 22). Additional support for this position is provided by Dreger and Aiken who conclude number anxiety appears to be a separate and distinct factor from general anxiety (1957).

Manifest trait anxiety is but one area of an array of personality attributes which may be involved in the incidence of mathematics anxiety. Other personality characteristics which may appear to influence whether a person is inclined towards mathematics anxiety include:

(a) how a person relates to uncertainty,
(b) the amount of toleration for floundering and risk-taking,
(c) the ability to deal with occasional failures,
(d) the inability to concentrate in the face of distraction and
(e) the tendency to persevere despite obstacles. (Tobias, 1978).

Since mathematics anxiety can be categorized as a performance anxiety (Oetting & Deffenbacher, 1980; Shodahl, 1985), certain elements of personality, especially self-image, may relate to one's ability to respond publicly to evaluative situations, which so frequently characterizes classes in mathematics. The requirement for speed and accuracy, a common element in mathematical tests, may "...become a source of stress, confusion and loss of control. The end may be an impaired self-image, leading inevitably to increased anxiety about math and to math avoidance" (Shodahl, 1984, p. 33).

2. Educational Influences:

Despite the overall purpose of education to facilitate the acquisition of knowledge to students, factors inherent in the teaching/learning process may actually serve to negatively influence the development of confidence in mathematics and may result in some manifestations of mathematics anxiety. In his essay on the subject, Hilton is terse and indicting. "...To use a medical metaphor, ... we are dealing (with respect to a cause of mathematics anxiety) with a mass infection caused by the virus of bad mathematics teaching" (Hilton, 1980, p. 176). To elaborate, the author cites "...bad teaching, bad texts and bad educational instruments as among the principal causes of math incompetence and math avoidance" (ibid.). Stodolsky addresses this issue in her criticism of the manner in which many classes in mathematics are conducted. She claims there exists a general lack of creative pedagogy in the use of what she terms "the restricted routes" (Stodolsky, 1985) to the learning of math. While appearing in other curricular areas, factors such as:

(a) the homogeneity in instructional methodologies in the preponderance of seat work and recitation,

(b) the lack of manipulatives,

(c) textbook-centered instruction,

(d) student reliance on the math teacher as perhaps the single resource for trouble-shooting problems and

(e) a lack of small group work or encouragement of peer tutoring

are frequently observed in mathematical education. Stodolsky's observational research of mathematics classes, found 48% of the class time was devoted to work in isolation at one's seat; 31% of available time was given to teacher recitations and the remaining time was devoted to test-taking, homework corrections, etc. (Stodolsky, 1985).

Perhaps it is the nature of the subject matter with its focus on detail and symbolism (Kogelman & Warren, 1978) and frequent reliance on memorization (Shodahl, 1985; Tobias, 1978) which becomes problematic for some students. Some researchers claim student reliance on memorization of formulas and definitions (Shodahl, 1985) and the ritualistic applications of algorithms (Hilton, 1986) as well as rote calculations of drill and practice and word problem sessions lead to too little understanding and internalization of the underlying mathematical concepts. "Such a strategy for passing a mathematics course may work up to a point...(perhaps elementary algebra) but beyond that point, the system begins to break down" (Shodahl, 1985, p.33). When students who have previously relied on ritual and rote learning attempt to study higher mathematics, they become aware their mathematical performance may not be at quite the level of their previous experiences and this can be contributory to the tension and uneasiness sometimes associated with the onset of mathematics anxiety.

Another shortcoming with respect to mathematics which distinguishes it from some other academic areas is the fact that mathematical skills, similar to those involved in the mastering of a foreign language, tend to build cumulatively on themselves (Lazarus, 1974). A student can easily become disadvantaged if some important gap in learning is experienced, especially if the gap occurs at a fundamental level of study. Without remediation of the problem, the student risks remaining in a deficit position with respect to mastery of future skills (Kogelman and Warren, 1978). The all-too-frequent use of timed tests (Tobias, 1978) may serve to detract from one's enjoyment of, and sense of accomplishment in mathematics. The lack of a perceived relevancy of certain courses in mathematics to the "real world" (Kogelman & Warren, 1978; Tobias, 1978), may contribute additional negative attitudes toward mathematics which risk deterioration into math avoidance and ultimately, mathematics anxiety.

The existence, prevalence and intensity of mathematics anxiety may have its beginnings with avoidance behaviors in selecting elective, non-mathematics courses at the expense of mastery in the algebra, geometry, trigonometry, pre-calculus series. While mathematics anxiety should not be claimed as the only cause of math avoidance, a relationship nevertheless appears to exist (Aiken, 1972; Betz, 1978; Tobias & Weissbrod, 1980). "The relationship between mathematics anxiety and mathematics avoidance (is) said to be that anxiety inhibits work, because in order to avoid the anxiety, the student will stop studying math...Even able students who elect not to take math courses for a number of years can lose skills and consequently self-confidence and this can also cause mathematics anxiety when they are faced with mathematical problems again" (Donady & Auslander cited in Tobias & Weissbrod, 1980, p. 65). Perhaps the confounding effect of mathematics avoidance and mathematics anxiety is particularly troublesome to older, non-traditional returning college students at both the undergraduate and graduate levels of college studies. These students appear to be at greater risk in the erosion of their confidence with respect to mathematical anxiety than are younger women (Betz, 1978; Hendel, 1977) or to male students in general.

Concomitant with avoidance tendencies is the effect of a poor background in mathematics contributing to high levels of mathematics anxiety. In assessing the prevalence and intensity of this construct among a college population, Betz found a moderately strong relationship between mathophobia and the number of years of mathematics studied in high school (1978). Alexander and Cobb support the relationship by concluding "students most likely to experience math anxiety in college seem to be students who do poorly in high school mathematics and who are inadequately prepared (for the rigors of college mathematics)" (1984, p.11).

A relationship between mathematics anxiety and test-taking anxiety also seems apparent. Betz has observed students exhibiting a higher mathematics anxiety index also seem to experience higher levels of general test anxiety (1978). Dew, Galassi and Galassi support this finding but qualify it slightly by concluding while the two constructs share a relationship, they are non-interchangeable and could not be considered synonymous (1984). This presents a difficult problem for researchers in the field of mathematics anxiety; since the most widely used scales for measuring mathematics anxiety are in the form of self-reporting, paper-and-pencil tests, it sometimes becomes difficult to distinguish the possibility of a confounding effect exerted from the influences of mathematics anxiety and test-taking anxiety (Tobias & Weissbrod, 1980).

Unwary teachers who hold either ambivalent or negative attitudes toward mathematics may be unintentionally engendering mathematics anxiety. With Dutton reporting 39% of his sample of prospective elementary school teachers admitted a lack of confidence in their arithmetic skills (1954), and Kogelman and Warren speculating because a majority of elementary teachers are female, who statistically report higher mathematics avoidance and anxiety levels than do males, concern for the role of teacher-inculcated negative attitudes may be justified (1978). While teachers have long been known to be capable of conveying enthusiasm for certain subjects to their students, the converse is also true; teachers who demonstrate lackluster attitudes toward mathematics risk great harm to their students. Not only is the beauty, fascination and elegance of numbers and their relationship to the real world overlooked and lost (Gardner, 1987), but students may "...take their cue from the teacher that mathematics must be a dull, pointless task. Sadly, almost every student comes to adopt this perspective sooner or later. Mathophobia is a highly communicable condition to which the young are especially liable" (Lazarus, 1974, p.22).

3. Cognitive Development:

While mathematics anxiety is unattributable to general intelligence, (Digilio, 1987; Dreger & Aiken, 1957; Lazarus, 1974;), some speculation on its relationship to cognitive development has been raised. Developmental theorists such as Piaget contend until cognitive development has passed from the concrete to the formal (or abstract) operational stage, a learner is "...incapable of true quantitative reasoning or performing any mathematical operation with real understanding" (Green & Laxon, p. 15).

Shodahl believes part of the problem underlying the development of mathematics anxiety may be traceable to the cognitive immaturity of high school graduates, who often have not made the transition mathematically from the Piagetian stage of concrete operations to one of formal abstractions (Shodahl, 1985). She refers to a study conducted by Renner in which it was found 50% of those entering a freshman class in college "...were not yet fully formally operational in their thinking" (Renner cited in Shodahl, 1985, p.33). Another related dimension for the failure to reach cognitive maturity by the end of high school may rest with the overall expository pedagogical methods (those in which the teacher leads the learner through a process of instruction rather than allowing student discovery of the process) which seem to predominate in mathematical instruction (Stodalsky, 1985). An indictment of this method is provided by Shodahl in her reference to the research conducted by Renner. "Traditional classroom instruction which does not encourage personal student investigation and discovery of concepts and ideas, actually retards the movement of students through the cognitive stages identified by Piaget" (Renner cited in Shodahl, p. 33). Yet, additional research conducted by Clute, found expository methods of mathematical instruction lessened mathophobia specifically among the highly math-anxious (1984).

4. Societal and Cultural Factors:

Perhaps the most salient feature in all the psychological and educational literature researched, concerns the higher prevalence of mathematics anxiety among women than men (Betz, 1978; Brown, R.M., 1979; Crosswhite, 1972; Digilio, 1987; Fennema & Sherman, 1976; Hendel, 1977; Kogelman &

Warren, 1978; Oetting & Deffenbacher, 1980). Like so many other areas of educational research, contradictory data have emerged. Two studies found no discrepancies between men and women with respect to their mathematical anxiety levels. Ohlson and Mein were unable to discern any differences between males and females in their study of anxiety levels among a college population (1977). They credit this result with the fact their sample was drawn primarily from a population of high achievers, evidencing solid backgrounds in high school mathematics and the relative absence of interruption from their studies of mathematics (ibid.). Resnick, Viehe, and Segal confirm this finding among a similar sample. They too credit the lack of mathematics anxiety levels between men and women in their study to the proportionately equivalent mathematical backgrounds demonstrated by their sample with respect to their course-taking experience, SAT scores and the relatively short elapsed time since the last exposure to formal mathematical studies (1982). Overwhelming support with respect to experiences in mathematics however, indicates a disparity in the mathematics anxiety levels between women and men in a less homogeneous college sample. Betz reported several writers have suggested this discrepancy due to "sex role socialization" (Stent, 1977; Tobias, 1976; Brookes et al. cited in Betz, p.442) and the manifestation in women is not only more prevalent, but more intense than for their male counterparts (Betz, 1978). Crosswhite traces the first occurrence of this mathematical disproportionality among women to the junior high school years. He observes girls continue to experience a greater increase in the development of negative attitudes throughout the high school years. But while their male counterparts are also experiencing a deterioration of attitudes with respect to mathematics, it is occurring at a slower rate than for females (1972). Using a sample comprised of predominantly inner-city black community college students, Brown confirmed the findings of other researchers in observing a higher incidence of mathematics anxiety among women than men (Brown, R. M., 1979). In keeping with the preponderance of research data which support a higher incidence of mathematics anxiety among college women, Fennema's research contends one aspect of this problem relates to an incongruity among the perceived cultural and occupational stereotypes which relegates mathematics to the realm of a "male domain" (Fennema & Sherman,1976). However, Rounds and Hendel were unable to confirm the stereotype of female students with high mathematics anxiety who perceived the study of mathematics and mathematics-related occupations as being particularly masculine bastions (1980b).

Perhaps it is the persistently low participation rate of women in mathematics courses which intensifies the problem of sexual stereotyping (Fennema, 1976). Llabre and Suarez support this view in stating "sex differences in mathematics anxiety can be found in students with low levels of mathematics background" (1985, p. 286). The disproportionately low representation of women in mathematical classes and their high attrition rates in these courses was reported at a rate nearly twice that for men (Ernest cited in Hendel, 1977). Llabre and Suarez conclude "... the amount of interaction with mathematics, not the variability of the sex of the individual relates to math anxiety at the college level" (1985, p.286).

Extending the concept of gender-related discrepancies associated with the acquisition of mathematical skills, there is some evidence of differential treatment resulting in females, to a greater extent than males, receiving inadequate mathematics education in high school (Fennema, 1980). Researchers at American University have demonstrated "...teachers by means of (their) acceptance, remediation, praise, as well as criticism pay more attention to males than females, with white boys receiving the most attention followed by minority boys, while white girls and minority girls trailed" (Sutton, 1986).

Fennema claims "...teachers...hold different expectations for male learners of math....They expect boys to be better problem solvers, to persist in their mathematical activities longer and to be more interested in math...." (Fennema, 1980, p.170). While teachers may appear to provide preferential treatment for boys, "...girls have been found to possess reduced expectations of themselves with respect to math that interfere with their willingness to persist in math problem solving" (Dweck cited in Tobias & Weissbrod, 1980 p. 64). Digilio claims "...diligence is a necessary ingredient for success (in mathematics)" (1987, p. 6) and lacking this quality, many women fall short of their potential achievement. It appears a depreciated self-concept of being competent as a learner of mathematics, coupled with certain teacher behaviors may place many girls at a mathematical disadvantage. Intrinsic and extrinsic factors may exert influences on the learner which predispose certain vulnerable students to avoid mathematics, ultimately nurturing attitudes consistent with mathophobia.

Noted sociologist, Lucy Sells, researched the mathematics preparation of women as they entered the class of 1976 as freshman at the University of California at Berkeley. In her _Fact Sheet on Women in Higher Education_, she reported 57% of the men presented with a background of four years of study in mathematics while a mere 8% of women were similarly prepared. Since admittance to ten of the twelve colleges at Berkeley required four years of study in mathematics during high school, 92% of the women were afforded restricted opportunities in their choice of an academic major and ultimately, the career options available to them (Brush, 1976; Tobias, 1978).

In addition to the gender-related aspects of mathematics anxiety, there are other societal and cultural influences which may have the effect of limiting the mathematical potential of both men and women. Included in this category are some of the so-called "myths" which appear to abound with mathematical studies. Kogelman and Warren describe twelve such popular false impressions which can claim a toll among the math-anxious:

(a) "Men are better in math than women";
(b) "Math requires logic, not intuition";
(c) "You must always know how you got the right answer";
(d) "Math is not creative";
(e) "There is a best way to do a math problem";
(f) "It's always important to get the answer exactly right";
(g) "It's bad to count on your fingers";
(h) "Mathematicians do problems quickly in their heads";
(i) "Math requires a good memory";
(j) "Math is done by working intensely until the problem is solved";
(k) "Some people have a 'math mind' and some don't";
(l) "There is a magic key to doing math" (Kogelman & Warren, 1978, pp.30-43).

The Prevalence and Intensity of Mathematics Anxiety:

Prior to 1978, little research was conducted specifically on the prevalence, intensity and distribution of mathematics anxiety among a college population. Before then, the incidence and intensity of mathematics anxiety was claimed to be under-reported (Lazarus, 1974) and studied only in conjunction with the validation of psychometric instruments (Dutton, 1954; Suinn, Edie, Nicolletti, & Spinelli, 1972). In establishing validity criteria for the Dutton Attitudes Scale, Dutton found 39% of the prospective elementary school teachers in his survey admitted a lack of confidence with respect to their skills in arithmetic (1954). In attempting to provide validation data for the MARS, researchers discovered 28% of their sample of some four hundred undergraduates "...exhibited extreme levels of tension associated with mathematical situations or number manipulation. Over one-third of the students who actively sought help through a counseling center behavior therapy program described their pressing problem as connected with mathematics" (Suinn, Edie, Nicolletti & Spinelli, 1972, p. 373). Six years later, conducting research solely on the prevalence, intensity and distribution of mathematics anxiety among college students, Betz reported "...math anxiety occurs relatively frequently among college students, and overall, females reported significantly higher levels of math anxiety than males" (1978, p.441). Kogelman's studies of graduate female students at Smith College found mathematics anxiety was common among this adult population (1978). Two years later, Howard, in a presentation to the Association of Teacher Educators, reported research appraisals which indicated mathematics anxiety and fear may have reached "epidemic proportions" (cited in Berebitsky, 1980, p. 21). Not quite as extreme in tone however, was the more moderate report of research by Alexander and Cobb which claimed mathematics anxiety occurred frequently at the college level (1984).

As is the situation in so many aspects of psychological and educational research, contradictory and confusing results have been published. Resnick, Viehe and Segal found among a group of high-achieving students at a private college with a selective admission policy, levels of mathematics anxiety were so significantly low, they questioned the existence of the mathematics anxiety construct (1982). The authors attempted to explain the phenomenon of low mathematics anxiety by describing the particularly strong mathematical backgrounds of their sample, as well as the fact the mean age of the group was eighteen years old, indicating very little time had elapsed since previous formalized studies of mathematics. The authors claim the value of their research effort appeared to be in demonstrating the non-generalizability of the existence and prevalence of mathematics anxiety from one institution to another (ibid.).

Performance Factors

An important purpose in focusing attention on the anxiety/confidence complex is to determine the possible effect this attitudinal predisposition exerts on performance in mathematics. The variables which influence student performance are complex and interactive; isolation of a single factor would be an oversimplification. Numerous studies appear to demonstrate at least a correlation between levels of mathematics anxiety and performance in mathematics as measured by ACT scores (Betz, 1978; Fenneman, 1974; Ohlsen & Mein, 1977; Whipkey, 1970), departmental diagnostics (Austin-Martin, 1980; Butler & Austin-Martin, 1981; Kincaid & Austin-Martin, 1981), and final grades (Dreger & Aiken, 1957; Morris, Kellaway & Smith, 1978; Sherman, 1979). But inconsistencies have also been reported; some researchers (Brown, R. M., 1979; Llabre & Suarez, 1985; Szetel as cited in Morris, Kellaway & Smith, 1978) reported no correlation between mathematics anxiety scores and performance in mathematics. Moderating this finding are those who report only a modest relationship between demonstrated achievement and mathophobia (Dew, Galassi & Galassi, 1984). Other research supports the contention mathematics anxiety, more than any other performance anxiety (Oetting & Deffenbacher, 1980), demonstrates a detrimental effect on achievement. Additional research reports high confidence levels correlate with high performance and demonstrated success in mathematics (Alexander & Cobb, 1984; Austin-Martin, 1980; Betz, 1978; Clute, 1984; Dreger & Aiken, 1957; Kincaid & Austin-Martin, 1981; Oetting & Deffenbacher, 1980).

Summary:

While contradictory data exist, it appears the mathematics anxiety/confidence complex has been documented as a significant entity which influences mathematical performance among some college populations. For at least a few students, a modicum of mathematics anxiety can be facilitative and associated with improved task performance (Alpert & Haber cited in Callahan, 1971; Sherard cited in Berebitsky, 1985). However, it is the more debilitating effects of mathematics anxiety which impede progress and career goals, which are the subject of this study.

The overwhelming body of research seems to indicate those most at risk appear to be:

1. primarily women (although men are not immune),
2. those with inadequate mathematics preparation at the high school level,
3. those with depreciated self-images with respect to their ability to learn mathematics,
4. the older student who, in returning to college, may have allowed a significant number of years to elapse since the last formal study of mathematics and lastly,
5. elementary school teachers and pre-service elementary teachers who demographically present a higher ratio of females to males and who may be at risk for possession of negative attitudes towards mathematics.

Common characteristics of this population are difficult to assess. The singular characteristic which seems to pervade this apparently diverse population is their general uncomfortableness with mathematics. As one mathophobe wrote,"...And on the eighth day, God created mathematics...He took stainless steel and he (sic) rolled it out thin, and he (sic) made it into a fence forty cubits high, and infinite cubits long. And when he (sic) was finished he (sic) said, 'On one side of this fence will reside those who are good at math. And on the other will remain those who are bad at math, and woe unto them, for they shall weep and gnash their teeth'" (Digilio, 1987, p. 6). This self-limiting "fence" has been determined to be mathematics anxiety. It need not, however, remain a permanent barrier to students in their mathematical endeavors. The focus of this research effort has been to determine if this construct, called mathematics anxiety, is contributing to under-performance in the diverse population of business calculus students and prospective elementary school teachers in introductory mathematics courses at Salisbury State College.

CHAPTER III

DESIGN OF THE INVESTIGATION

This research was undertaken at Salisbury State College in Salisbury, on Maryland's Eastern Shore during the fall, 1987 semester. Its purpose was to identify the existence, prevalence and intensity of the construct "mathematics anxiety" among nearly 350 undergraduate students enrolled in two introductory mathematics courses, and to examine the relationship between mathematics anxiety and achievement in those courses. Students' scores on the confidence and anxiety segments of the Fennema-Sherman Mathematics Attitude Scales were cross-classified by means of contingency tables and compared with final grades in the mathematics courses for which they had enrolled, to determine the value of using the mathematics anxiety scale as a predictor of mathematical achievement in those courses.

Subjects:

The subjects involved in this research effort included 346 student volunteers enrolled in two introductory mathematics courses: MATH 103 (Fundamental Concepts in Mathematics), and MATH 150 (Algebra with Calculus). To avoid criticism of sample bias, design of the research utilized the entire population of students in these courses, permitting greater generalizability for these courses in future semester.

MATH 103 (Fundamentals of Mathematical Concepts) is a course intended for prospective elementary school teachers and is usually studied during the freshman year at Salisbury State College. Course composition has traditionally demonstrated a majority of female students. All sections of MATH 103 were utilized in this study.

MATH 150 (Algebra with Calculus) is an introductory mathematics course which was typically studied in the freshman year at Salisbury State College. This course, (or more difficult course substitutes, MATH 160 (Applied Calculus) or MATH 201 (Analytic Geometry and Calculus I)) must be satisfactorily completed with a grade of C or better before acceptance into the Business Administration program. The Department of Mathematical Sciences has expressed concern about this course; despite competency testing using the Mathematical Sciences Department Diagnostic Test (MSDDT), lack of successful achievement has averaged 52.8% over a five semester period (Cashman, L., 1987). Students earning deficient grades must either re-enroll in MATH 150, or change their major area of study to one other than Business Administration. In an attempt to gain further insight into the problem of underachievement in this course, all ten sections of MATH 150 were included in this study.

While most subjects participating in this study were freshmen, students beyond their first year of collegiate study were found in the population under scrutiny if (a) declaration of a major was either postponed or changed, (b) the course was being repeated, or (c) a student was using the introductory course as a "refresher" prior to more advanced studies in mathematics or science.

Description of Instruments/Materials

Materials used in conducting this research project included: a Research Disclosure Form (RDF), Student Consent Form (SCF), Mathematics Anxiety Research Survey which included student biographical data and the Fennema-Sherman Mathematics Anxiety and Confidence Scales (FSMAS/FSMCS), a single test of the Test Anxiety Profile (TAP), and the Mathematical Sciences Departmental Diagnostic Test (MSDDT).

1. Research Disclosure Form (RDF) - (See Appendix A):

The Human Volunteers Committee at Salisbury State College requires all students participating in research projects to be provided with disclosure forms outlining the purpose of the research effort. All subjects were informed that participation in the research study would be on a voluntary basis, and that participation and/or performance in the research project would have no effect on final course grades. Students were reassured once group data had been collected, all linkage between their names, social security numbers and survey responses, (other than scores on the MSDDT, which are maintained separately by the Mathematical Sciences department) would be destroyed. These forms also provided information pertaining to where interventional strategies and/or additional references on the subject of mathematics anxiety might be obtained.

2. Student Consent Form (SCF) - (See Appendix B):

The SCF provided signed permission, allowing access to each subject's SAT-MATH scores and final course grades.

3. Mathematics Anxiety Research Survey - (See Appendix C):

Items 1-4 represent student biographical data; 5-15 represent the Test Anxiety Profile; 16-27 the Fennema-Sherman Mathematics Anxiety Scale; 28-39 the Fennema-Sherman Mathematics Confidence Scale.

A. Student Biographical Data: The first (4) questions in the survey dealt with obtaining student biographical information. Using a multiple choice format with five ranges of responses per question, information pertaining to student age, sex, number of years of study in high school mathematics, and the number of elapsed years since study in the last course in mathematics, was obtained.

B. Test Anxiety Profile (TAP): Developed by E.R. Oetting and J.L. Deffenbacher, the TAP consists of a battery of concept-specific, test anxiety instruments, which are copyright-protected and available only through Rocky Mountain Behavioral Science Institute, Inc., P.O. Box 1066, Fort Collins, Colorado 80522. The TAP purports to measure the anxiety a person generally experiences under different types of test situations. Students who completed the TAP were asked, "How do you feel when you take any test (other than a test in mathematics)?" By means of a semantic differential format, responses were provided by a variety of descriptors representing opposite dimensions of student reactions. The semantic differential was adapted to contain (5) rather than (7) items and scoring ranged from a low of "1", indicating high general test anxiety, to a high of "5", indicating confidence under general test conditions.

Internal consistency data were reported from .88 to .96 with test reliabilities reported between .66 to .81. Longitudinal construct validity data over a twelve year period confirmed the TAP was a measure of concept-specific test anxiety (Oetting & Deffenbacher, 1980).

The inclusion of the TAP in this study was based on the following criteria:

(1) Since general test anxiety can exert a confounding effect on mathematics anxiety (both in the respect that (a) surveys of mathematics anxiety are usually reported in the form of paper-and-pencil tests and (b) the usual means of evaluating mathematics performance in educational settings is through testing situations), differentiation of test anxiety and mathematics anxiety was attempted.

(2) The TAP was readily available on campus since multiple copies were maintained by the Counseling Center.

(3) The format of the eleven-item TAP lent itself to ease of administration.

C. The Fennema-Sherman Mathematics Attitudes

Scales:

Under a grant from the National Science Foundation, Fennema and Sherman were commissioned to design a multidimensional mathematics attitudes survey. The results of their research were published in 1976 and included nine, domain-specific attitudes toward the study of mathematics. Nine areas were identified:

(1). mathematics anxiety,

(2). confidence in one's mathematical ability,

(3). attitudes toward success in mathematics,

(4). mathematics as a male domain,

(5). effectance motivation,

(6). perceived usefulness of mathematics,

(7). teachers' attitudes toward one as a learner of mathematics,

(8). father's attitudes toward one as a learner of mathematics,

(9). mother's attitudes toward one as a learner of mathematics.

The authors claim the attitudinal instrument can be used as a total package, or individual scales can be utilized in assessing specific attitudes. Each of the nine domain-specific surveys consists of twelve items, obtained on a five-point, Likert-type scale. Responses range from a score of (1), implying strong disagreement, to a score of (5), indicating strong agreement. Since six of the twelve items are positively worded and six are negatively worded, the scoring of the negatively worded items are reversed to permit consistency in scoring. As a result, students achieving high scores on the scales demonstrate generally positive attitudes toward mathematics, while those students scoring low on the attitudes scales typically demonstrate poorer attitudes toward mathematics.

Two of the nine scales comprising the attitudinal survey were utilized in this study and scoring on the selected scales remained consistent with that established by the developers of the instrument:

(1) The Fennema-Sherman Mathematics Anxiety Scale (FSMAS) - has been described as "...intend(ing) to measure feelings of anxiety, dread, nervousness and associated bodily symptoms relating to doing mathematics. The dimension ranges from feelings of ease, to those of distinct anxiety" (Fennema & Sherman, 1976, p. 4).

(2) The Fennema-Sherman Mathematics Confidence Scale (FSMCS) - is "...intended to measure confidence in one's ability to learn and to perform well on mathematical tasks. The dimension ranges from

distinct lack of confidence to definite confidence" (ibid.).

Reliability of these instruments has been demonstrated by its authors and other researchers (Fennema & Sherman, 1976; Betz, 1978; Wikoff and Buchalter, 1986). Using split-half reliabilities, the anxiety scale demonstrated correlation coefficients of .89, while the confidence scale appeared to correlate at .93 (Fennema & Sherman, 1976). Multiscale factor analyses were conducted (ibid.; Wikoff and Buchalter, 1986) and it was found that the Fennema-Sherman Mathematics Attitudes Scales measured eight, not nine factors, with the anxiety and confidence scales actually measuring the same dimension of attitude, but at opposite polarities.

In another study, Broadbooks, Elmore, Petersen and Whaley described a correlation of .89 between anxiety and confidence levels (1981). However because attitudes of confidence and anxiety cannot coexist due to their inverse relationship, the correlation coefficient should more accurately be expressed as -.89.

The Fennema-Sherman instruments were originally tested with high school subjects but studies have successfully utilized the scales with college undergraduate and graduate students (Betz, 1978; Wikoff & Buchalter, 1986; et al.).

D. The Mathematical Sciences Departmental Diagnostic Test (MSDDT) - (See Appendix D):

The MSDDT is a self-assessment skills "placement" test used to predict success in introductory college mathematics courses at Salisbury State College. Developed in the mid 1970's by then faculty member, Dr. David Parker of the Mathematical Sciences department, and later modified by Shultz (1985), its use in this study included all students in each section of MATH 103 and 150. The Mathematical Sciences department selected this diagnostic test over commercially available material because it required only ten minutes to administer and graded tests were able to be returned within the context of the first class meeting. Also, the test measures skills considered particularly important in most introductory mathematics courses. The test features ten, multiple-choice questions and for purposes of this study, scoring of the test indicated the number of correct item responses. Each question lists five responses labeled A through E. Four of the five possible answers are in numerical form, while the fifth answer for all questions takes the form, "none of these". Items follow a conventional pedagogical scheme with the first questions requiring only arithmetic skills, followed by algebraic expressions, ending with higher degree equations using two or more unknowns (Shultz, 1985).

Reliability coefficients between SAT-MATH and the MSDDT were found to be .52 (ibid.). This is considered to be a good reliability coefficient and indicates the self-assessment test measures what it purports to measure, i.e., mathematical skill (ibid). Validity coefficients using MSDDT scores and final grades were reported at the .35 level (ibid). The implication is that while this correlation is small, it nevertheless is significant.

Procedures

1. Preliminary Activities:

Prior to the actual implementation of the research, a presentation was required before the Committee on Human Volunteers of Salisbury State College, to outline the scope of the project. Once the committee received assurance that subjects were without risk in participating in the study, research approval was provided on May 26, 1987 (See Appendix F).

Approval was secured from each of the individual instructors scheduled to teach sections of MATH 103 and MATH 150 to allow testing during class time. Testing was conducted by the researcher, except in situations where sections involved in this study met simultaneously. When such conflicts arose, a member of the Mathematical

Sciences department familiar with the research project assisted in conducting the survey.

Research materials consisted of a Research Disclosure Form, Student Consent Form, Mathematics Anxiety Research Survey containing student biographical information, the Test Anxiety Profile, Fennema-Sherman Mathematics Anxiety and Confidence Scales, a single answer sheet for the three attitude surveys, the Mathematical Sciences Department Diagnostic Test with its own answer sheet, scratch paper, and pencils for machine scoring of tests. Based on enrollment data submitted by the Registrar's office, sufficient materials were delivered to each classroom prior to the start of each class.

To increase efficiency, items were organized into three categories for distribution:

(a) Research Disclosure Form,

(b) Packet I (the SCF, Mathematics Anxiety Research Survey containing biographical information, questions relating to the TAP, FSMAS, FSMCS and a single, consolidated, thirty-nine item answer sheet for responses.

(c) Packet II (containing the MSDDT and a separate, ten-item answer sheet).

Organization of materials into packets was necessary due to the different characteristics of items in each group.

1) Packet I:

(a) included untimed survey materials for the TAP, SCF, FSMAS and FSMCS;

(b) required a single, consolidated, thirty-nine item answer sheet for recording responses to biographical items, TAP, FSMAS and FSMCS.

(c) immediate scoring of these test items was unnecessary

(d) directions assured students that Packet I materials would have no bearing on class placement or final course grade;

(e) assurances were given to test-takers that any linkage between student name, social security number, and results of this section of the survey would be eliminated once group data collection had taken place;

2). Packet II:

(a) included the MSDDT, which is a timed skills-based diagnostic test required by the Mathematical Sciences department in certain introductory courses, and is administered each semester exclusive of this research in certain introductory mathematics courses (usually excluding MATH 103 students)

(b) required a separate ten-item answer sheet;

(c) use of the MSDDT required immediate scoring, permitting students who were found with skills deficiencies to be recommended for placement in another, more appropriate mathematics class;

(d) student placement in certain introductory mathematics courses was predicated on performance on the MSDDT;

(e) linkage between student name and performance on the MSDDT remained permanently on file with the Department of Mathematical Sciences;

Sequencing of the survey items was considered an important element in the design of this study in mathematics anxiety. Because of the possibility of a confounding effect from the diagnostic test contaminating student responses to the confidence/anxiety scales, the following sequencing was prescribed:

(a) distribution of the Research Disclosure Form,
(b) issuance of Packet I to all subjects,
(c) followed by Packet II to all students.

2. Administration of the Survey Items:

During the first class session of each section in MATH 103 and MATH 150, subjects were informed, by this researcher or a representative from the faculty of the Mathematical Sciences department, that research on the existence of mathematics anxiety was being conducted. Instructors were advised to avoid the use of the word "test" when possible, substituting instead, words such as "instrument", "battery", "scales", "profile" or "survey". For accuracy of record-keeping, instructors were also asked to write on the chalkboard the course and section number of each class. Since retrieval of data relied on the use of social security numbers by class section, accurate reporting of this information was important.

Students were told that only a few minutes of class time would be required for participation in the study. Research Disclosure Forms were distributed and reassurances of the ramifications involved in participation in the study were provided. Once students appeared to be familiar with the research project, they were told the survey would be conducted in two parts:

(a) Part 1 was untimed and consisted of a consent form, biographical information and three surveys of student attitudes which were to be carefully entered on the provided answer sheet, and

(b) In Part 2, the MSSDT would be administered. A mathematics department requirement allowed ten minutes for completion of the ten questions.

Next, Packet I was circulated to each subject. Packet I materials included the Student Consent Form, Mathematics Anxiety Research Survey including the Test Anxiety Profile, Fennema-Sherman Mathematics Anxiety and Confidence Scales, a thirty-nine item, machine scorable answer sheet, and pencils appropriate for machine scanning. Students were instructed to first complete the SCF, making certain correct social security and course section numbers were used. Then, the Mathematics Anxiety Research Survey including student biographical data and the three attitude scales were scored on a single answer sheet. Biographical information was required in questions 1 - 4 while the TAP featured questions 5 - 15, FSMAS, 16 - 27, and FSMCS, 28 - 39. As students completed Packet I, they were reminded to check the accuracy of their social security numbers and class sections on their answer sheets and then return the materials to the proctor's desk/table and await distribution of Packet II. When all materials had been collected, they were counted and assembled into three envelopes labeled: (a) SCF (b) machine scorable answer sheets (c) Mathematics Anxiety Research Survey. Each envelope was identified by course and section numbers, along with the total number of respondents listed.

Packet II was then distributed and contained the MSSDT, answer sheet and scratch paper. Students entered correct name, social security number and class section on the answer sheet and were reminded not to begin until told, at which time ten minutes would be provided for completion of the ten-item self-assessment instrument. Since the diagnostic form was reusable among students in other mathematics courses, students were urged to exercise care in avoiding any extraneous marks to the question sheets. All notations, other than indications of the correct answer on the answer sheets, were to be made on scratch sheets which would be collected and discarded at the end of the class period. Assurances were provided that performance on the diagnostic test would have no bearing on final course grades, its use being restricted only to an attempt to accurately place students in the mathematics course most appropriate for their skill level. Students were instructed to begin, and to answer all questions. After ten minutes had elapsed, students surrendered their answer sheets, questionnaires, and scratch sheets. The class was then remanded to the assigned instructor for the balance of the class period. Materials were immediately assembled by the class proctor (or designated assistant from the Department of Mathematical Sciences) and immediately scored, with the number of correct answers listed at the bottom of each answer sheet. Before the end of the first class session, corrected tests were returned to each instructor in MATH 150 classes only. (Under non-research conditions, MATH 103 students would not ordinarily be required to complete the MSDDT; their inclusion was only for purposes of gathering data for this study). Students scoring above a certain predetermined standard were advised they had a high probability for success in MATH 150 and were advised to remain in class. However, those scoring below a predetermined standard were advised they probably would experience difficulty in MATH 150 and suggested to transfer to either Intermediate Algebra or Developmental Mathematics, classes more appropriate for their skills level. As a result of the transfer, many of these students were lost from the study.

3. Follow-Up Activities:

The SCF's were provided to the Registrar's office for retrieval of SAT-MATH information for each student and final course grades at the end of the fall semester. Subjects' scores on the FSMAS, FSMCS and TAP were machine scanned and responses were weighted numerically so that low scores on the anxiety, confidence, and general test anxiety scales indicated poor attitudes, while high scores indicated positive attitudes. Analysis of the data awaited submission of final course grades in mid December, 1987.

Evaluation Procedure:

All data compiled for use in this research effort were processed by means of student social security numbers. The following data were initially utilized for each subject:

(a) student social security number,
(b) FSMAS score,
(c) FSMCS score,
(d) TAP score,

(e) MSDDT score

(f) final course grade,

(g) SAT-MATH score,

(h) sex of the student, (Sex)

(i) age of the student, (Age)

(j) number of years of study in high school mathematics, (Preparation)

(k) number of elapsed years since last course in mathematics. (Hiatus)

Use of a student's social security number was initially necessary because it provided the only means of extracting SAT-MATH scores from student transcripts, and obtaining final course grades in each of the mathematics classes involved in the study. Once this data had been collated, all individual social security numbers were deleted, yielding only group data. Such action destroyed the possibility of any linkage with individual students, their social security numbers or their responses to the research surveys.

Research Questions

The primary purpose of this research was to determine the prevalence and intensity of mathematics anxiety among students in two introductory college mathematics courses and to examine the relationship between mathematics anxiety and achievement in those two courses. To better assess the value of using mathematics anxiety as a predictor of success, the research also sought to weigh the relative value of mathematics anxiety as a predictor of success in these mathematics courses against the value of SAT-MATH scores, a content-based diagnostic test, the level of high school mathematics preparation, and the amount of elapsed time since the last formal study of mathematics was undertaken.

A second purpose of this study was to examine the relationship between mathematics anxiety to confidence toward mathematics, generalized test anxiety, age, sex, SAT-MATH scores, scores on a content-based mathematics diagnostic test, level of high school mathematics preparation, and the amount of time elapsed since the last formal study of mathematics.

In order to address the specific objectives of this study, (see p. 7 in Statement of Problem), the following research questions were formulated:

1. Does mathematics anxiety exist in the surveyed population?
2. Is mathematics anxiety related to confidence in mathematics?
3. Is mathematics anxiety related to general test

anxiety, as measured by the Test Anxiety Profile for this survey population?

4. What relationship, if any, exists in comparing mathematics anxiety with other variables, specifically age, sex, level of high school mathematics preparation, length of hiatus from formal studies of mathematics, and scores on the SAT-MATH?
5. Is a score on the Fennema-Sherman Mathematics Anxiety Scale related to student performance on the Mathematical Sciences Department Diagnostic Test (MSDDT) for MATH 150 students?
6. Are the mathematics anxiety scores for subjects in this study related to their success, as measured by the final course grades in MATH 103 and MATH 150?
7. What relative importance can be ascribed to mathematics anxiety in predicting student achievement in the courses investigated in this research effort?
   a) Is the FSMAS a better predictor of success in MATH 150 and in MATH 103 (as separate courses) than the current diagnostic test (MSDDT)?
   b) How will the FSMAS fare in predicting success in introductory mathematics courses (both MATH 150 and MATH 103) when considered along with other predictors, specifically the

MSDDT, SAT-MATH scores, hiatus from formal study of mathematics and level of high school mathematics preparation?

Statistical Technique:

The data were analyzed using the SPSSX statistical program on the Digital VAX 8300 computer at Salisbury State College. Cross-classifications in the form of contingency tables for each category of the variables were computed and analyzed. The variables were as follows:

> FSMAS scores, FSMCS scores, SAT-MATH scores, MSDDT scores, TAP scores, age, sex, years of high school mathematics, years since last mathematics course, final grades.

Cross-classifications of the levels of the variables as contingency tables were provided so independence or dependence could be established via chi-square tests. Also, cross-classifications allowed examination of the distributions of the variables across the subpopulations corresponding to the two courses.

Regression analysis of the data was used to determine predictive validity of the FSMAS, with respect to mathematical achievement, as measured by final course grades. Multiple regression analyses were also utilized in determining the relative value as predictors of achievement from among the factors: FSMAS, SAT-MATH, MSDDT scores, number of years of study in high school mathematics and the number of years of elapsed time since the last course in mathematics was studied.

CHAPTER IV

ANALYSIS OF DATA

Introduction

The purpose of this study was to explore the existence of mathematics anxiety among students in two introductory mathematics courses at Salisbury State College. Once identified, the relationships of mathematics anxiety to such variables as mathematics confidence, achievement in mathematics courses, and certain biographical traits were investigated. Additionally, an attempt was made to investigate the usefulness of these variables, especially that of mathematics anxiety, to predicting achievement in a course of study in mathematics. Data were compiled from student responses to surveys completed in all sections of "Algebra with Calculus" (MATH 150) and all sections of "Fundamental Concepts of Mathematics" (MATH 103). The survey was conducted on the first day of classes during the fall, 1987 semester. Additional statistics were provided by the office of the Registrar at Salisbury State College.

Analysis of Subjects

The study population consisted of 346 college underclassmen (Table 1). Of these, 105 students were enrolled in MATH 103 and 241 students were enrolled in MATH 150. Overall, 60.4% of the population were female.

Table 1.

Sex of Survey Population

	Sex				Total	
	Female		Male			
Course						
103	98	93.3%	7	6.7%	105	100.0%
150	111	46.1%	130	53.9%	241	100.0%
Total	209	60.4%	137	39.6%	346	100.0%

An examination of the age distribution of the surveyed population revealed that only 11.8% were in the category of non-traditionally aged college students (Table 2), i.e., students who were twenty-two years of age or older. In the oldest age classification, more MATH 103 students were represented (N = 19) than were MATH 150 (N = 6).

Age of Survey Population

Table 2.

	Age							
	15-18		19-21		22-25		+26	
Course								
103	39	37.1%	43	41.0%	4	3.8%	19	18.1
150	153	63.5%	69	28.6%	12	5.0%	6	2.5
Total	192	55.7%	112	32.5%	16	4.6%	25	7.2

The level of high school preparation in "academic" mathematics subjects, i.e., introductory and intermediate algebra (with or without trigonometry), formal geometry, and calculus or pre-calculus) was investigated as a variable possibly affecting mathematics anxiety. For purposes of this study, data were analyzed according to the following scheme:

<2 years	- no academic exposure to mathematics or one year of study
<3 years	- two years of study generally including introductory algebra and either formal geometry or intermediate algebra (with or without trigonometry)
<4 years	- three years of mathematics including introductory and intermediate algebra (with or without trigonometry) and formal geometry
4 years	- introductory and intermediate algebra (with or without trigonometry), formal geometry, and pre-calculus or calculus

The level of high school preparation for the surveyed group indicated a higher exposure to mathematics among the MATH 150 students than among the MATH 103 students.

Table 3.

Level of Preparation for College Mathematics

	Mathematics Preparation			
	Unprepared		Prepared	
Course				
103	12	11.4%	93	88.6%
150	14	5.9%	224	94.1%
Total	26	7.6%	317	92.4%

The length of time allowed to elapse since the last formal study of mathematics was examined (Table 4). Nearly half (46.5%) the population had experienced a recent exposure to mathematics, i.e., formal study within the last six months, while only 10.8% were found to have a four or more year hiatus from mathematics studies.

Table 4.

Years Since Study of Formal Mathematics

	Hiatus from Formal Mathematics									
	- 6 mos		1 year		2 years		3 years		4/+4years	
Course										
103	34	32.4%	26	24.8%	18	17.1%	5	4.8%	22	21.0%
150	126	52.7%	57	23.8%	30	12.6%	11	4.6%	15	6.3%
Total	160	46.5%	83	24.1%	48	14.0%	16	4.7%	37	10.8%

Since scores on the Scholastic Aptitude Tests (SAT) are widely used in predicting the probability of success in college, the Registrar's office was asked to provide scores (Table 5) for the mathematics component of the SAT (SAT-MATH); however, it was found that 22.5% of the subjects lacked SAT information. The reasons the scores were not available for these students are not known but may be due in part to an exemption of SAT scores for students who are admitted to college at least five years after high school graduation, or who are classified as special or part-time students at the time of their admission to the college.

Table 5.

Scholastic Aptitude Test Scores in Mathematics

	SAT - M		
	Mean	Standard Deviation	Valid N
Course			
103	448	83	72
150	491	74	196
Total	480	78	268

Generally, MATH 103 students demonstrated lower SAT-MATH scores overall (X = 448), with a greater variance than was indicated by those enrolled in MATH 150 (X = 491).

Analysis of Results

In designing this study, seven areas of inquiry emerged from the formulated research questions (see p. 66). Data were analyzed specifically in response to each of the proposed research questions and a display of the data for addressing each area of inquiry, with statistical analysis when appropriate, is provided:

1. Does mathematics anxiety exist in the surveyed population?

Student responses (ranging from "1", indicating high anxiety to a score of "5", indicating non-anxiety) were classified according to the following intervals:

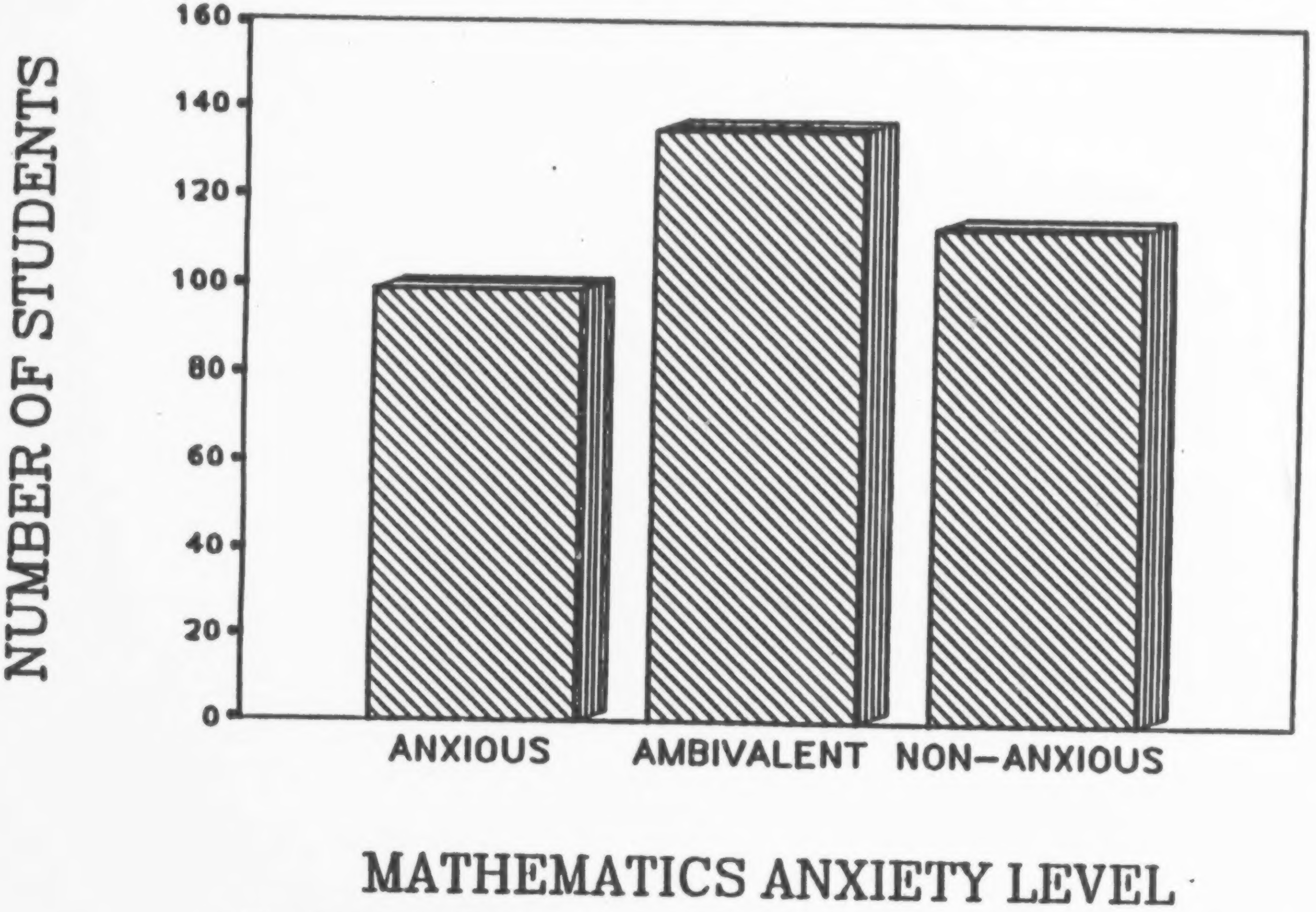
1.00 - 2.49	Anxious
2.50 - 3.49	Ambivalent
3.50 - 5.00	Non-anxious

Therefore, a low score on the FSMAS indicated high mathematics anxiety while a high score represented a lack of anxiety. Mathematics anxiety was found to exist in the population (Figure A). Nearly one-third, or 100 of the 346 subjects were classified as anxious.

Examination of the distribution of mathematics anxiety across students in the two subpopulations, revealed differences (Table 6, Figures B and C). The percentages of anxious students in MATH 103 and MATH 150 were 38.1% and 24.5% respectively. A chi-square test showed that the interdependence of mathematics anxiety and program of study was marginally significant ($p < 0.03$).

Figure A

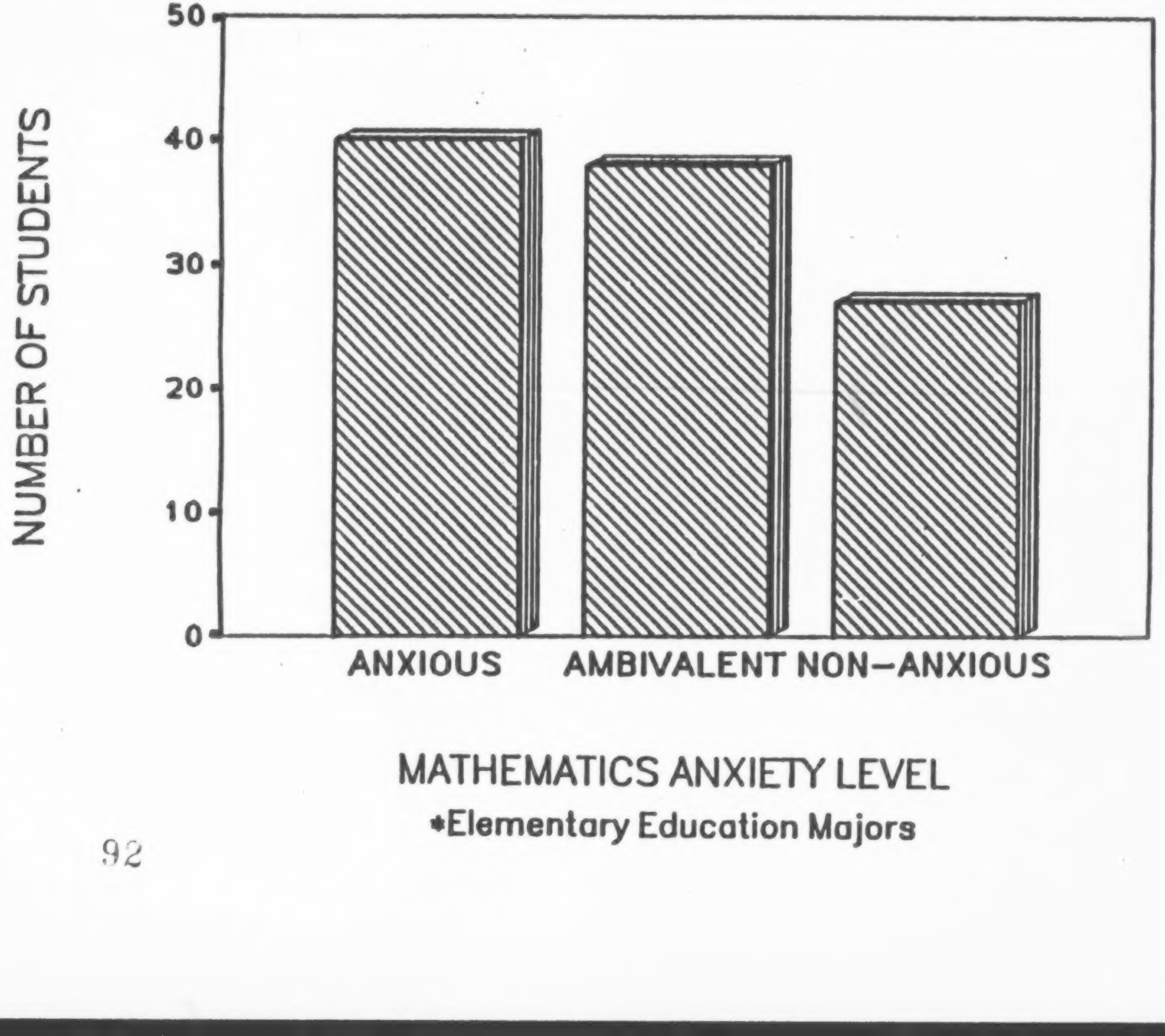
MATHEMATICS ANXIETY LEVELS FOR SURVEY POPULATION*



*Elementary Education and Business Administration Majors

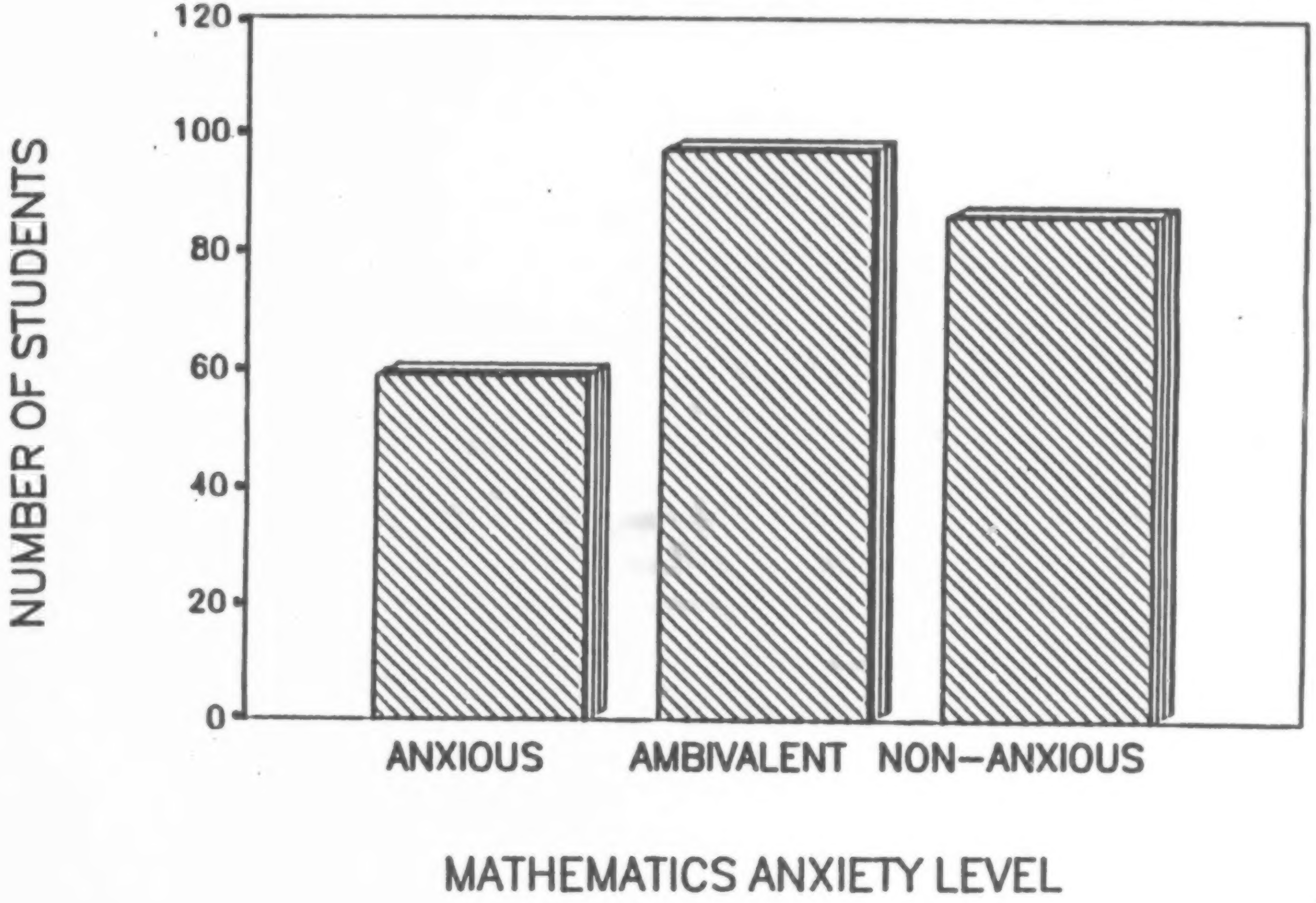
Figure B

MATHEMATICS ANXIETY LEVELS FOR STUDENTS IN FUNDAMENTAL CONCEPTS OF MATHEMATICS*



*Elementary Education Majors

Figure C
MATHEMATICS ANXIETY LEVELS
FOR STUDENTS IN ALGEBRA WITH CALCULUS*



*Business Administration Majors

Levels of Mathematics Anxiety for Survey Population

Table 6.

	Mathematics Anxiety					
	Anxious		Ambivalent		Non-anxious	
Course						
103	40	38.1%	38	36.2%	27	25.7%
150	59	24.5%	97	40.2%	85	35.3%
Total	99	25.6%	135	39.0%	112	32.4%

Chi-square = 7.10906 (2, N=346) p-value = 0.0286

2. Is mathematics anxiety related to confidence in mathematics?

For purposes of analyzing data in this study, the following classifications were determined for mathematics confidence, as measured by the Fennema-Sherman Mathematics Confidence Scale.

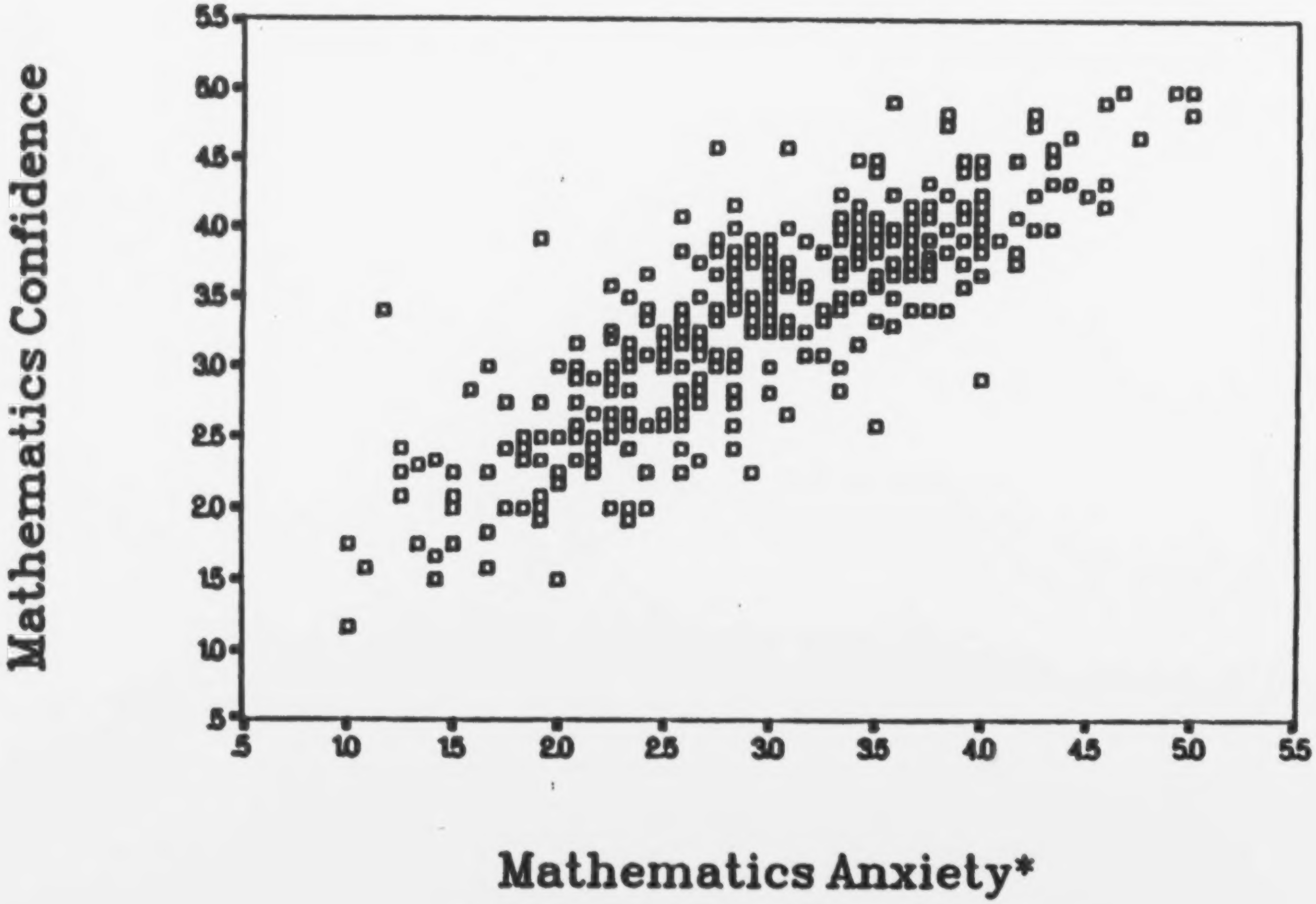
1.00 - 2.49	Non-confident
2.49 - 3.49	Ambivalent
3.50 - 5.00	Confident

Therefore, a low score on the FSMCS indicated a lack of self confidence in one's ability to study mathematics and a high score represented confidence.

As a result of analysis, it can be determined mathematics anxiety and confidence in mathematics are traits which are not independent of one another. The scatter plot (Figure D) suggests mathematics anxiety and confidence in mathematics are related, indicating that confident students possess less mathematics anxiety and conversely, non-confident students possess more

Figure D

Mathematics Anxiety and Mathematics Confidence



*Low scores on math anxiety scale indicate high levels of math anxiety mathematics anxiety. It should be noted in analyzing Figure D that an inverse relationship between mathematics anxiety and confidence in mathematics emerged. Due to the manner of scoring the anxiety and confidence scales, whereby low scores for both scales indicated negative attitudes, a positive slope resulted in the scatter plot display.

Analysis of contingency tables are widely used to assess the dependence or independence of two variables. A contingency table for mathematics confidence versus mathematics anxiety is provided in Table 7. A chi-square test showed that anxiety and confidence in mathematics are not independent ($p < 0.0001$).

Table 7.

Comparison of Confidence/Anxiety Levels for Survey Population

	Mathematics Anxiety					
	Anxious		Ambivalent		Non-anxious	
Mathematics Confidence						
Non-confident	47	90.4%	5	9.6%		
Ambivalent	48	40.3%	63	52.9%	8	6.7%
Confident	4	2.3%	67	38.7%	102	59.0%

Chi-square = 213.29130 (4, N=344) p-value <0.0001

3. Is mathematics anxiety related to general test anxiety, as measured by the Test Anxiety Profile, for this survey population?

A cross-classification for general test anxiety and mathematics anxiety is displayed below (Table 8). A scatter plot (Figure E) is also provided. A chi-square test showed that the interdependence of general test anxiety and mathematics anxiety was insignificant (p = 0.2821).

Table 8. **General Test Anxiety and Mathematics Anxiety**

	Mathematics Anxiety					
	Anxious		Ambivalent		Non-anxious	
General Test Anxiety						
Anxious	11	31.4%	13	37.1%	11	31.4%
Ambivalent	62	30.7%	83	41.1%	57	29.2%
Non-anxious	26	23.9%	39	35.8%	44	40.4%

Chi-square = 5.05095 (4, N=346) p-value = 0.2821

4. What relationship, if any, exists in comparing mathematics anxiety with other variables, specifically, age, sex, level of high school mathematics preparedness, hiatus from formal study of mathematics and scores on the SAT-MATH?

Age: A cross-classification for age and mathematics anxiety appears in Table 9. A chi-square test showed that the interdependence of age and mathematics anxiety was insignificant (p = 0.3917).

Figure E

Mathematics Anxiety and Test Anxiety Profile

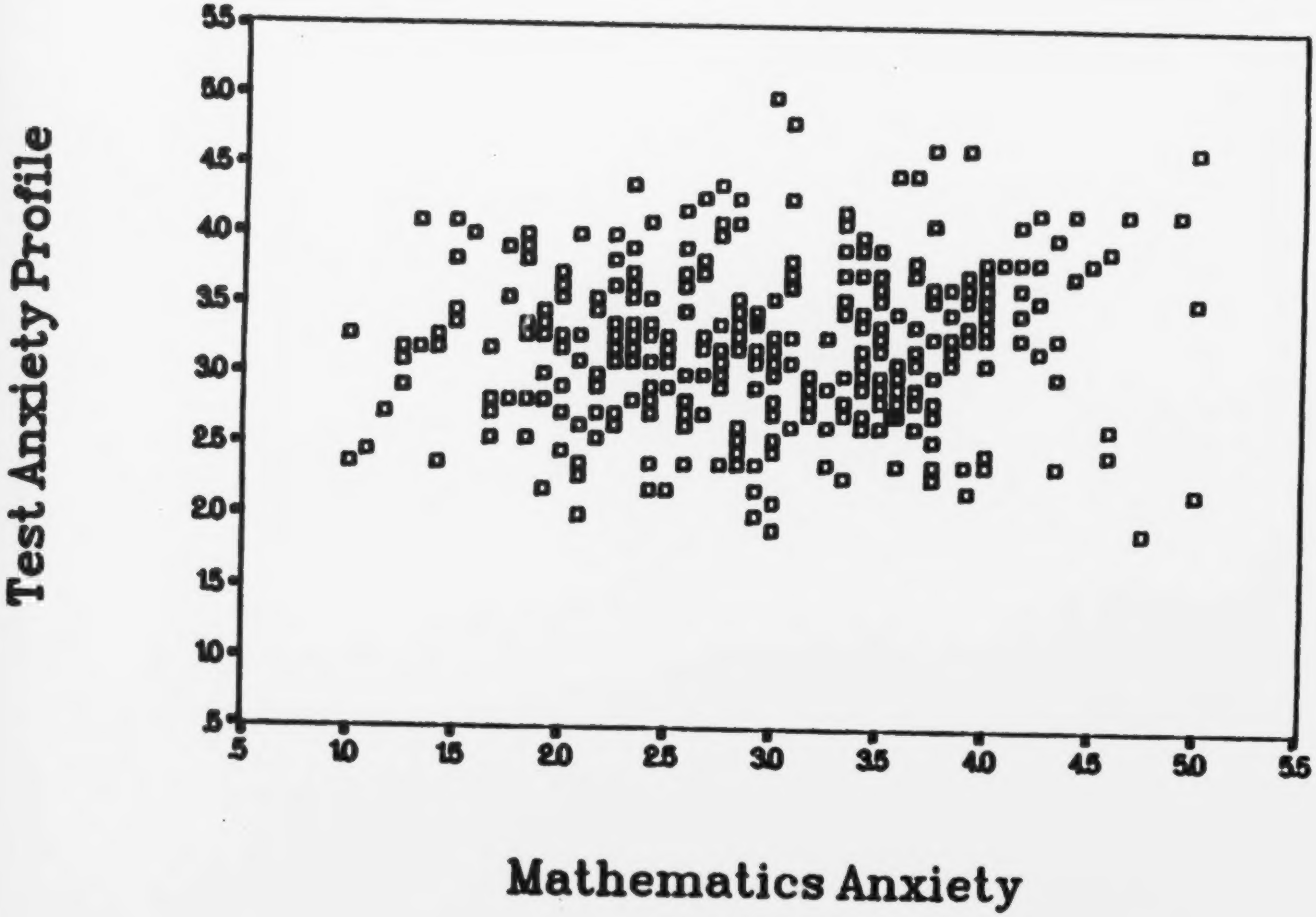


Table 9.

Mathematics Anxiety and Age

	Mathematics Anxiety					
	Anxious		Ambivalent		Non-anxious	
Age						
16-18	45	23.4%	73	40.6%	69	35.9%
19-21	37	33.0%	43	38.4%	32	28.6%
22-25	6	37.5%	6	37.5%	4	25.0%
+26	10	40.0%	8	32.0%	7	28.0%

Chi-square = 6.28779 (6, N=345) p-value = 0.3917

Sex: Of the 209 females involved in the study, 32% of the females reported mathematics anxiety, compared to 23.3% of the males surveyed (Table 10). However, a chi-square test showed that the interdependence of sex and mathematics anxiety was insignificant (p = 0.2147).

Table 10.

Mathematics Anxiety and Sex

	Mathematics Anxiety					
	Anxious		Ambivalent		Non-anxious	
Sex						
Female	67	32.1%	78	37.3%	64	30.6%
Male	32	23.4%	57	41.6%	48	35.0%

Chi-square = 3.07669 (2, N=346) p-value = 0.2147

Levels of High School Mathematics Preparation: A chi-square test showed that the interdependence of mathematics anxiety and the amount of mathematics studied at the high school level was significant ($p < 0.0001$) (Table 11).

Table 11.

Mathematics Anxiety and Mathematics Preparation (Business Calculus Students)

	Mathematics Anxiety					
	Anxious		Ambivalent		Non-anxious	
Level of Mathematics Preparation						
Less than 2 Years	5	2.1%	3	1.3%	6	2.5%
2 Years	12	5.0%	11	4.6%	2	.8%
3 Years	30	12.6%	40	16.8%	26	10.9%
4 Years	10	4.2%	42	17.6%	51	21.4%

Chi-square = 32.14779 (6, N=238) p-value < 0.0001

Hiatus From Formal Study of Mathematics: A chi-square test showed that the interdependence of mathematics anxiety and elapsed time from mathematics study was only marginally significant ($p = 0.0285$) (Table 12).

Table 12.

Mathematics Anxiety and Hiatus from Formal Mathematics

	Mathematics Anxiety					
	Anxious		Ambivalent		Non-anxious	
Hiatus from Formal Mathematics						
- 6 mos	37	23.1%	58	36.3%	65	40.6%
1 year	23	27.7%	40	48.2%	20	24.1%
2 years	15	31.3%	19	39.6%	14	29.2%
3 years	6	37.5%	5	31.3%	5	31.3%
4/+4years	18	48.6%	11	29.7%	8	21.6%

Chi-square = 17.16338 (8, N=344) p-value = 0.0285

SAT-MATH Scores: A chi-square test showed the interdependence of mathematics anxiety and SAT-MATH score was significant (p < 0.0001). Those students reporting lower SAT-MATH scores exhibited higher levels of mathematics anxiety than were reported among those students scoring higher on the SAT-MATH (Table 13).

Table 13.

Mathematics Anxiety and SAT-Mathematics Scores

	Mathematics Anxiety					
	Anxious		Ambivalent		Non-anxious	
SAT - M						
<= 450	39	33.2%	43	42.2%	20	19.6%
451-550	28	22.8%	54	43.9%	41	33.3%
551-800	3	7.0%	14	32.6%	26	60.5%

Chi-square = 28.91459 (4, N=268) p-value < 0.0001

5. Is a score on the Fennema-Sherman Mathematics Anxiety Scale (FSMAS) related to student performance on the Mathematical Sciences Department Diagnostic Test (MSDDT) for MATH 150 students?

The MSDDT is an institutionally-designed instrument which provides nearly immediate feedback to both students and instructors indicating a student's likelihood of success in certain introductory mathematics courses at Salisbury State College. (MATH 103 students usually do not participate in this diagnostic screening, although for data analysis purposes of this study, they were asked to complete the test.) Previous research in MATH 150 classes, has indicated students found to score between 0 - 5 items correct were likely to have a 24% chance of success in MATH 150, as compared with students achieving 6 - 10 correct items who would have a 66% probability of success. (Schultz, S. and Austin, H., 1987). In keeping with these research results, the following designations were used in classifying MSDDT scores:

0 - 5 correct responses	Probability of unsuccessful course performance
6 - 10 correct responses	Probability of successful course performance

Table 14. **Mathematics Anxiety and MSDDT Scores Business Calculus Students**

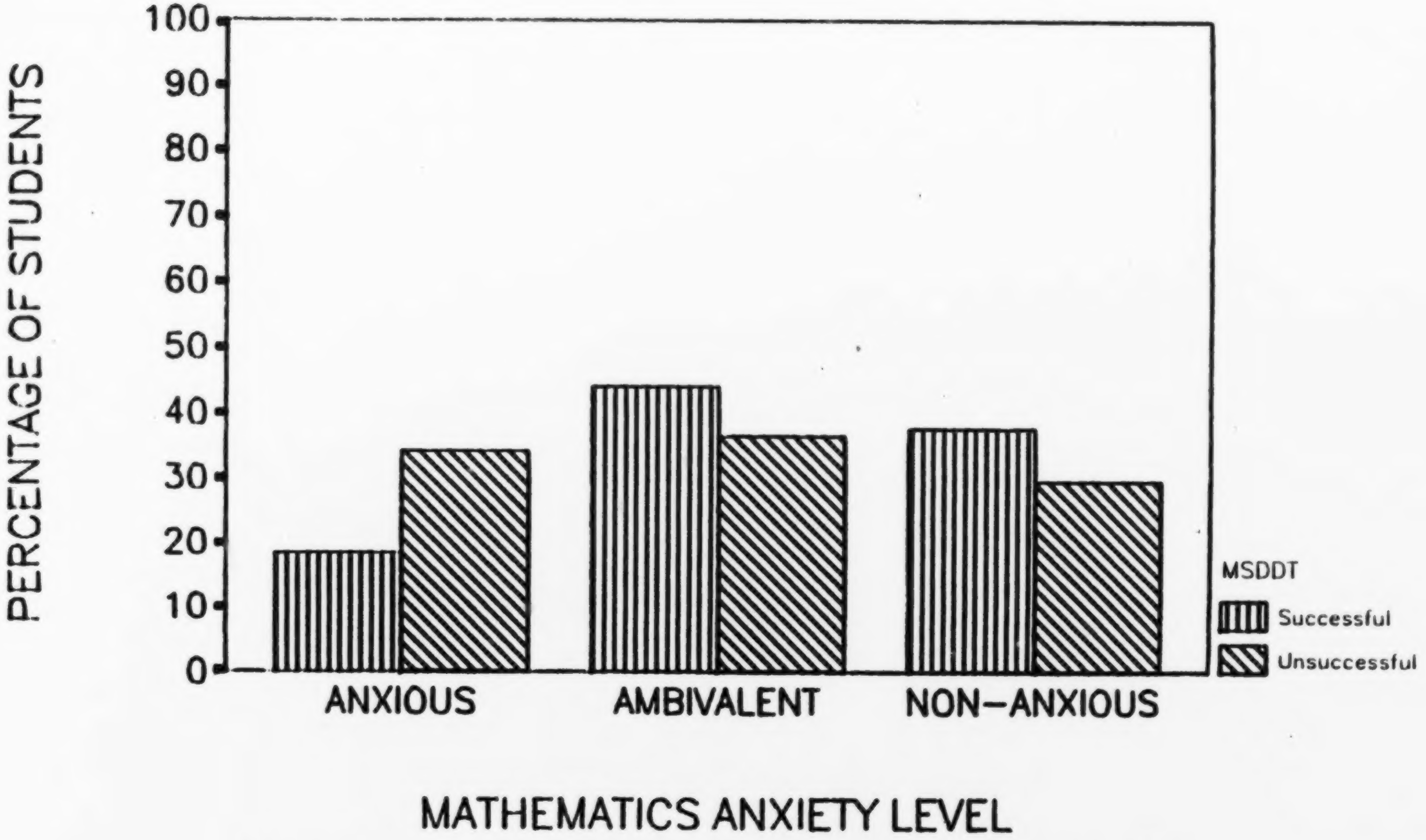
	Diagnostic Test Results			
	Unsuccessful		Successful	
Mathematics Anxiety				
Anxious	30	13.1%	26	11.4%
Ambivalent	32	14.0%	62	27.1%
Non-anxious	26	11.4%	53	23.1%

Chi-square = 7.20774 (2, N=229) p-value = 0.0272

A chi-square test showed that the interdependence of mathematics anxiety and performance on the MSDDT was marginally significant ($p < 0.0272$). Unsuccessful students showed higher anxiety than successful students (Table 14). Figure F is included to descriptively display this relationship.

FIGURE F

COMPARISON OF MATHEMATICS ANXIETY LEVELS
WITH SCORES ON THE MATHEMATICAL SCIENCES DIAGNOSTIC TEST
(Business Calculus)



Chi-square = 7.20774 (2, N = 229) P-value = 0.0272

6. Are the mathematics anxiety scores for subjects in this study related to their success, as measured by the final course grades in MATH 103 and MATH 150?

This question was approached by assigning values of "Successful" and "Unsuccessful" to final grades achieved in each of the introductory mathematics courses involved in this study. Final grades of "A", "B", "C" were defined as successful, while "D", "F" and "W" were deemed unsuccessful achievement. Investigation of the effect of anxiety on course achievement was approached both from the perspective of the effect upon the entire survey population and more closely from the effect on each of the subpopulations. Chi-square tests showed the interdependence of mathematics anxiety and success in a mathematics course were insignificant (Tables 15, 16, 17). However, in the case of MATH 150 students, only 19% of the anxious students were successful whereas 38% of the non-anxious and 42.9% of the ambivalent students were successful (Table 17). This trend is further illustrated by observing that, as a group, the anxious students tended to be unsuccessful (Figure G), while the non-anxious students tended to be successful.

Table 15.

Mathematics Anxiety and Final Grades
Total Population

	Mathematics Anxiety					
	Anxious		Ambivalent		Non-anxious	
Level of Achievement in Mathematics Course						
Unsuccessful	47	32.6%	57	39.6%	40	27.8%
Successful	50	25.5%	78	39.8%	68	34.7%

Chi-square = 2.72962 (2, N=340) p-value = 0.2554

Table 16.

Mathematics Anxiety and Final Grades
Elementary Education Majors

	Mathematics Anxiety					
	Anxious		Ambivalent		Non-anxious	
Level of Achievement in Mathematics Course						
Unsuccessful	14	41.2%	14	41.2%	6	17.6%
Successful	26	37.1%	24	34.3%	20	28.6%

Chi-square = 1.48663 (2, N=104) p-value = 0.4755

Table 17.

Mathematics Anxiety and Final Grades
Business Calculus Students

	Mathematics Anxiety					
	Anxious		Ambivalent		Non-anxious	
Level of Achievement in Mathematics Course						
Unsuccessful	33	30.0%	43	39.1%	34	30.9%
Successful	24	19.0%	54	42.9%	48	38.1%

Chi-square = 3.99232 (2, N=236) p-value = 0.1359

7. What relative importance can be ascribed to mathematics anxiety in predicting student achievement in the courses investigated in this research effort?

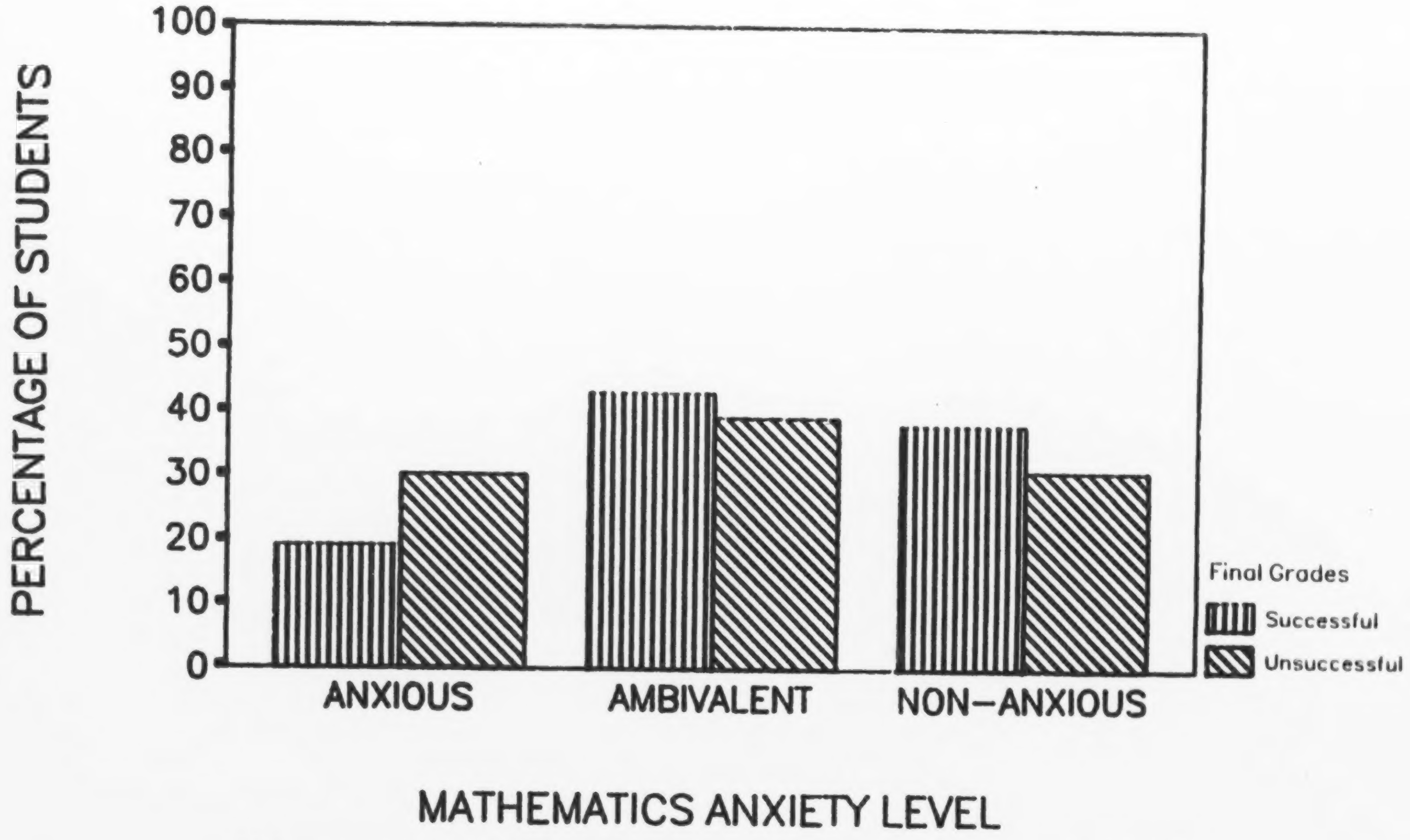
a) The FSMAS was compared to the diagnostic test (MSDDT) to assess its worth as a predictor of success in MATH 150 and in MATH 103 as separate courses. A forward method in multiple linear regression was used to make these comparisons.

In MATH 150, the diagnostic test was found to be the best single predictor (Table 18) and once this variable was in the equation, the FSMAS was not allowed to enter. Thus, once the variability in achievement (11%) explained by the diagnostic test has been accounted for, the additional contribution of the FSMAS is insignificant ($p = .1658$).

IGURE G

COMPARISON OF MATHEMATICS ANXIETY LEVELS WITH FINAL COURSE GRADES

(Business Calculus)



Chi-square = 3.99232 (2, N = 236) P-value = 0.1359

Table 18: Linear Regression Analysis of FSMAS and MSDDT as a Predictor of Final Course Grades for Business Calculus Students.

```
Equation Number 1    Dependent Variable..   CORSGRAD
Beginning Block Number  1.  Method:  Forward

Variable(s) Entered on Step Number
   1..    DIAGN     DIAGNOSTIC TEST SCORE

Multiple R            .32941
R Square              .10851
Adjusted R Square     .09969
Standard Error       1.15050

Analysis of Variance
                     DF      Sum of Squares       Mean Square
Regression            1            16.27273          16.27273
Residual            101           133.68843           1.32365

F =       12.29385        Signif F =  .0007

------------------ Variables in the Equation ------------------

Variable              B          SE B        Beta          T   Sig T

DIAGN           .143920       .041047     .329413      3.506   .0007
(Constant)     1.328052       .217912                  6.094   .0000

------------- Variables not in the Equation -------------

Variable     Beta In   Partial   Min Toler         T   Sig T

ANXAVG       .144998   .138268     .810645     1.396   .1658
```

In MATH 103, a similar result was obtained (Table 19).

Table 19: Linear Regression Analysis of FSMAS and MSDDT as a Predictor of Final Course Grades for Education Majors Studying Fundamental Concepts of Mathematics.

```
Equation Number 1    Dependent Variable..   CORSGRAD

Beginning Block Number  1.  Method:  Forward

Variable(s) Entered on Step Number
   1..     DIAGN      DIAGNOSTIC TEST SCORE

Multiple R            .38464
R Square              .14795
Adjusted R Square     .14411
Standard Error       1.33397

Analysis of Variance
                     DF       Sum of Squares       Mean Square
Regression            1             68.59522          68.59522
Residual            222            395.04317           1.77947

F =       38.54804        Signif F =  .0000

------------------ Variables in the Equation ------------------



Variable                  B         SE B        Beta           T   Sig T

DIAGN               .251047      .040435     .384642       6.209   .0000
(Constant)          .028031      .268825                    .104   .9170

------------- Variables not in the Equation -------------

Variable      Beta In   Partial   Min Toler          T   Sig T

ANXAVG        .092768   .098352     .957705      1.469   .1432

End Block Number   1    PIN =       .050 Limits reached.
```

b) A forward method in multiple linear regression was used to assess an order of worth as predictors of success among the variables: the FSMAS (ANXAVG), MSDDT (DIAGN), high school mathematics preparation levels (BIOG3), length of hiatus from formal study of mathematics (BIOG4) and SAT-MATH score. This method was used in both MATH 150 and MATH 103 courses.

In MATH 150 (Table 20), it was found that the diagnostic test and SAT-MATH score were the best predictors of success in this order, explaining 20% of the variation in the grades obtained in the course. Once this variation is accounted for, the additional contributions of the remaining variables are insignificant (FSMAS (ANXAVG), p = .42; level of high school preparation (BIOG3), p = .11; and hiatus from mathematics studies (BIOG4), p = .94).

Table 20: Linear Regression Analysis of Research Variables as Predictors of Final Course Grades for Business Calculus Students.

```
Equation Number 1    Dependent Variable..   CORSGRAD
Beginning Block Number  1.  Method:  Forward

Variable(s) Entered on Step Number
   1..    DIAGN      DIAGNOSTIC TEST SCORE

Multiple R              .41519
R Square                .17238
Adjusted R Square       .16773
Standard Error         1.28788

Analysis of Variance
                        DF      Sum of Squares      Mean Square
Regression               1            61.49304         61.49304
Residual               178           295.23474          1.65862

F =      37.07477         Signif F =  .0000

------------------ Variables in the Equation ------------------

Variable              B          SE B        Beta          T  Sig T

DIAGN           .276753      .045452     .415188      6.089  .0000
(Constant)     -.252320      .309441                  -.815  .4159

------------- Variables not in the Equation -------------

Variable     Beta In  Partial  Min Toler         T  Sig T

ANXAVG       .093181  .100391    .960645     1.342  .1812
SAT          .211892  .197329    .717767     2.678  .0081
BIOG3        .126826  .134876    .936024     1.811  .0718
BIOG4      -.002077 -.002240     .963001     -.030  .9763

         * * * *   M U L T I P L E   R E G R E S S I O N   * * * *
Equation Number 1    Dependent Variable..   CORSGRAD

Variable(s) Entered on Step Number
   2..    SAT        SATINT, SATCOLL 'SAT Scores'

Multiple R              .45234
R Square                .20461
Adjusted R Square       .19562
Standard Error         1.26611

Analysis of Variance
                        DF      Sum of Squares      Mean Square
Regression               2            72.98909         36.49455
Residual               177           283.73869          1.60304

F =      22.76579         Signif F =  .0000

------------------ Variables in the Equation ------------------

Variable              B          SE B        Beta          T  Sig T

DIAGN           .201718      .052742     .302619      3.825  .0002
SAT             .003376      .001485     .211892      2.678  .0081
(Constant)    -1.723541      .627988                 -2.745  .0067

------------- Variables not in the Equation -------------

Variable     Beta In  Partial  Min Toler         T  Sig T

ANXAVG       .056443  .060582    .684650      .805  .4218
BIOG3        .112218  .121316    .695706     1.621  .1067
BIOG4        .005005  .005503    .702861      .073  .9419
```

Table 21: Linear Regression Analysis of Research Variables as Predictors of Final Course Grades for Education Majors Studying Fundamental Concepts of Mathematics.

```
Equation Number 1    Dependent Variable..   CORSGRAD
Beginning Block Number  1.  Method:  Forward

Variable(s) Entered on Step Number
   1..    DIAGN       DIAGNOSTIC TEST SCORE

Multiple R              .42284
~~R Square                .17880~~
Adjusted R Square       .16690
Standard Error         1.10630

Analysis of Variance
                       DF          Sum of Squares        Mean Square
Regression              1                18.39346           18.39346
Residual               69                84.47978            1.22434

F =      15.02310        Signif F =  .0002

------------------ Variables in the Equation ------------------
Variable                B         SE B        Beta            T  Sig T

DIAGN             .184689      .047630     .422844        3.876  .0002
(Constant)        .997884      .280307                    3.560  .0007

------------- Variables not in the Equation -------------
Variable      Beta In  Partial  Min Toler          T  Sig T

ANXAVG        .103964  .104216    .826839       .866  .3906
SAT           .245209  .242278    .984926      2.059  .0433
BIOG3         .013942  .013069    .719398       .108  .9146
BIOG4         .316473  .338230    .937962      2.964  .0042

        * * * *   M U L T I P L E   R E G R E S S I O N   * * * *
Equation Number 1    Dependent Variable..   CORSGRAD

Variable(s) Entered on Step Number
   2..    BIOG4       Hiatus from Formal Mathematics

Multiple R              .52225
~~R Square                .27274~~
Adjusted R Square       .25135
Standard Error         1.04892

Analysis of Variance
                       DF          Sum of Squares        Mean Square
Regression              2                28.05790           14.02895
Residual               68                74.81533            1.10023

F =      12.75098        Signif F =  .0000

------------------ Variables in the Equation ------------------
Variable                B         SE B        Beta            T  Sig T

DIAGN             .213119      .045360     .501671        4.698  .0000
BIOG4             .322450      .108796     .316479        2.964  .0042
(Constant)        .117715      .336495                     .350  .7274

------------- Variables not in the Equation -------------
Variable      Beta In  Partial  Min Toler          T  Sig T

ANXAVG        .109865  .115987    .784638       .964  .3384
SAT           .280163  .271680    .860795      2.311  .0239
BIOG3         .037343  .037063    .695731       .304  .7624

        * * * *   M U L T I P L E   R E G R E S S I O N   * * * *
Equation Number 1    Dependent Variable..   CORSGRAD

Variable(s) Entered on Step Number
   3..    SAT         SATINT, SATCCLL 'SAT Scores'

Multiple R              .57133
~~R Square                .32642~~
Adjusted R Square       .29626
Standard Error         1.01697

Analysis of Variance
                       DF          Sum of Squares        Mean Square
Regression              3                33.58003           11.19334
Residual               67                69.29321            1.03423

F =      10.82291        Signif F =  .0000

------------------ Variables in the Equation ------------------
Variable                B         SE B        Beta            T  Sig T

DIAGN             .151667      .053875     .346737        2.815  .0065
BIOG4             .331966      .105563     .325819        3.145  .0025
SAT               .004088      .001769     .280163        2.311  .0239
(Constant)      -1.365520      .754186                   -1.811  .0747

------------- Variables not in the Equation -------------
Variable      Beta In  Partial  Min Toler          T  Sig T

ANXAVG        .006281  .006338    .568869       .051  .9591
BIOG3        -.055173 -.053354    .592247      -.439  .6621
```

In MATH 103 (Table 21), the best predictors of success were the diagnostic test, hiatus from mathematics studies and SAT-MATH score and these variables explain 33% of the variation in course grades. Once this variation has been accounted for, the additional contributions from the other two variables are insignificant (FSMAS [ANXAVG], p = .96; and level of high school preparation [BIOG3], p = .66).

CHAPTER V

SUMMARY, FINDINGS, DISCUSSION, IMPLICATIONS, CONCLUSIONS, AND RECOMMENDATIONS

Summary

In general, a myriad of factors contribute to student performance in studies of mathematics. Of particular interest to this researcher was the facilitative, neutral or debilitative influence of mathematics anxiety in predicting student achievement at the college level in introductory mathematics courses. While evaluative instruments such as the Scholastic Aptitude Test purport to indicate a general ability to succeed in college, the notion of aptitude as it is currently measured, precludes some affective variables which influence achievement. Specifically, where mathematics anxiety has been reported, what may appear superficially as an aptitude problem, may in fact be a non-intellectual, emotionally-based obstacle to the learning of mathematics.

The primary purpose of this research was to examine the relationship between mathematics anxiety and achievement in mathematics among two introductory college level mathematics courses. To better assess the value of mathematics anxiety as a predictor of success, this investigation attempted to weigh the relative value of mathematics anxiety as a predictor of success in these mathematics courses against the value of the SAT-MATH, the Mathematical Sciences Departmental Diagnostic Test, a content-based diagnostic test, the level of high school mathematics preparation, and the amount of elapsed time since the last formal study of mathematics was undertaken. A secondary purpose of the study was to examine the relationship of mathematics anxiety to confidence, general test anxiety, age, sex, SAT-MATH scores, scores on a content-based mathematics diagnostic test, level of high school mathematics preparation and the amount of time elapsed since the last formal study of mathematics was undertaken.

The study was conducted during the fall semester of 1987 at Salisbury State College in Salisbury, Maryland. 346 undergraduates who represented the entire population of students enrolled in all sections of MATH 103, "Fundamental Concepts of Mathematics", (a course intended for prospective elementary school teachers), and all sections of MATH 150, "Algebra with Calculus", (a course intended for business administration majors), were tested on the first day of classes using the Fennema-Sherman Mathematics Anxiety Scale and the Fennema-Sherman Mathematics Confidence Scale in order to measure the existence, prevalence and intensity of the constructs "mathematics anxiety" and "confidence towards mathematics". Additionally, an adapted version of the Test Anxiety Profile was administered in an attempt to distinguish general test anxiety from mathematics anxiety. Biographical information pertaining to a subject's age, sex, level of high school mathematics preparation and the amount of time elapsed since the last class in mathematics studied was also collected. Permission was granted to the researcher to access each student's SAT-MATH scores and final course grades. To complete the survey, a short, institutionally-designed placement test which measures arithmetic and algebraic skills found to be prerequisite for mastery in certain introductory mathematics courses at Salisbury State College was also administered to each research subject. The data were then quantified and analyzed. Cross-classifications of the levels of the variables were provided so independence or dependence was established via chi-square tests. Regression analyses were used to determine predictive validities for the referenced variables with respect to mathematics anxiety levels.

Findings

Within the limitations of this study, for the population of the study, and based on the data accumulated, the following research findings were derived:

1. Mathematics anxiety was found to exist among the surveyed population. Anxious, ambivalent and confident students existed at about the same percent. As a group, elementary education students marginally appeared to possess more mathematics anxiety than did the business majors.

2. Evidence was found that mathematics anxiety and confidence towards mathematics were inversely related traits in the surveyed population. Anxious students tended to be less confident in their attitudes towards mathematics and confident students demonstrated lower anxiety levels.

3. Mathematics anxiety and general test anxiety were found to be independent traits.

4. Mathematics anxiety was found to be related to a student's score on the SAT-MATH and a student's level of high school mathematics preparation. Shown to have a marginal relationship with mathematics anxiety was the length of hiatus from formal studies in mathematics. No relationship to mathematics anxiety was found between a student's age and sex.

5. Mathematics anxiety and a score on the MSDDT were found to be related.

6. Mathematics anxiety and success in an introductory course in mathematics (as measured by final course grade), were found to be independent traits.

7. a) As a single predictor of success in either MATH 150 or MATH 103, the MSDDT was found to be better than the FSMAS.

b) When multiple factors were considered for MATH 150 students, the MSDDT and SAT-MATH were found to be the best predictors of success. When multiple factors were considered for MATH 103 students, the MSDDT and length of hiatus from formal studies of mathematics were found to be the best predictors of success.

Discussion of the Findings

While mathematics anxiety was found to exist among the surveyed population, scores on the Fennema-Sherman Mathematics Anxiety Scale were not found to be significant predictors of the level of student achievement in introductory mathematics courses. Other indicators, specifically, the SAT-MATH score, Mathematical Sciences Departmental Diagnostic Test score and the length of hiatus from the formal study of mathematics were decidedly better indicators of success for this group.

The insignificance of a mathematics anxiety rating to predict achievement was an unexpected result since the preponderance of research literature appears to establish a meaningful correlation between mathematics anxiety and student performance. In attempting to explain this result, several possible theories are offered:

1. While some anxious students fail to achieve success in a mathematics course, this study may demonstrate the conscientiousness of anxious students whereby their mathematics anxiety becomes facilitative in their attempts towards achievement. Likewise, students demonstrating low anxiety may in fact, lack conscientiousness and consequently, low anxiety which might ordinarily be viewed as a positive attitude, may in fact, for some students more closely resemble a non-productive attitude which adversely affects achievement.

2. Due to the nature and topic of this research, students and faculty may have been provided with heightened awareness and sensitivities about mathematics anxiety, and subliminal attempts at diffusions could have taken place during the semester.

3. It has been reported by Resnick, Viehe and Segal (1982) that considerable variations of mathematics anxiety exist among college populations. The caliber of students and the nature of the academic institutions are but two variables contributing to a lack of uniformity. Specifically at Salisbury State College, mathematics classes are generally small, rarely exceeding thirty students. The relatively small class size, the utilization of student tutors to provide readily available assistance to students in introductory mathematics courses, and the overall accessibility of mathematics

faculty may have in themselves and in combination provided opportunities throughout the semester not only for reduction of mathematics anxiety levels from those reported on the first day of classes, but also positively influenced academic achievement.

4. The fact each of the two introductory mathematics courses were specific requirements for the respective majors of the two course subpopulations, may have increased the on-task performance in each course. Had the survey been undertaken in general mathematics courses or designed for study of students not enrolled in a mathematics course, the outcome may have been more predictable.

Another important finding of this study was the discrepancy in mathematics anxiety levels between the two course subpopulations. Initially, the two groups presented different levels of mathematics skills as evidenced by an SAT-MATH score for MATH 103 students (X = 448) compared to the MATH 150 students (X = 491) (see Table 5). Upon collection of the data indicating levels of anxiety and confidence to mathematics, a noticeable difference emerged. Prospective elementary school teachers reported a discernibly higher presence of mathematics anxiety than reported by the business administration students. As might be expected, the incidence of confidence with respect to mathematics was lower among the education majors than their business major counterparts. This tends to corroborate findings as early as 1954 (Dutton) which indicated negative attitudes about mathematics were evident in prospective elementary school teachers.

Implications

While this research specifically undertook a study of the relationship of mathematics anxiety to achievement in two introductory courses in mathematics at the college level, the Fennema-Sherman Mathematics Confidence Scale was also administered to the research subjects. Since anxiety and confidence towards mathematics were found to represent opposite polarities of the same dimension, preliminary evidence suggests that confidence toward mathematics is a significant predictor of academic achievement.

Prospective elementary school teachers in this survey possessed lower SAT-MATH scores, higher rates of mathematics anxiety and lower confidence levels with regard to mathematics than the general population surveyed. One wonders if they risk inculcating their own attitudes relating to mathematics anxiety to their students, thus risking contributing to another generation of math phobics.

Since mathematics anxiety was found to exist and was found to be inversely related to confidence toward mathematics, and although significance to achievement was not established, these affective variables are important considerations and efforts might be undertaken to identify students possessing mathematics anxiety.

Conclusions

Subject to the limitations inherent in the study, the analysis of the data appeared to support the following conclusions:

1. Mathematics anxiety did appear to exist in the survey population at approximately an equal distribution level to ambivalence and confidence towards mathematics. Distribution of mathematics anxiety was reported at different levels in the two course subpopulations, with the elementary education majors reporting more anxiety than their counterparts in business administration. Overall, mathematics anxiety did not appear to be debilitative in contributing to a lack of success in either of the courses surveyed. In fact, the facilitative aspect of mathematics anxiety which may impel a student toward increased on-task application, may be operating in this group.

2. General test anxiety was found to exist among the research population but appeared to exist independent of mathematics anxiety.

3. The determination of a relationship between mathematics anxiety and other variables, specifically, confidence towards mathematics, levels of performance on the SAT-MATH, the Mathematical Sciences Departmental Diagnostic Test scores and the amount of high school mathematics preparation, appeared to be significant in predicting college achievement in an introductory mathematics course.

4. For the general survey population, a student's hiatus from formal mathematical studies produced marginally significant results, as did scores on an institutionally-designed placement instrument for the MATH 150 group, when compared to levels of mathematics anxiety and achievement.

5. While female students have been reported to demonstrate a higher incidence of mathematics anxiety and generally exhibit poorer performance in mathematics at the post-secondary level, this study failed to implicate a subject's sex and age as a significant factor affecting mathematics anxiety or achievement levels.

Recommendations

In view of the results of the study and this investigator's experience in conjunction with this research, the following recommendations for further study are offered:

1. Further investigation of the phenomenon of mathematics anxiety among students not presently enrolled in mathematics courses should take place. Since debilitative mathematics anxiety often compels a student to avoid interaction with mathematics, additional attempts should be undertaken to repeat this study specifically among students who have selected majors where a mathematics requirement does not exist.

2. Preliminary evidence from this study suggests a relationship of confidence in one's ability to perform well in mathematics and actual achievement as evidenced by a successful final course grade. The use of the Fennema-Sherman Mathematics Confidence Scale as a predictor of success in introductory courses of mathematics should be studied.

3. The ramifications of confidence in mathematics to the variables used herein with mathematics anxiety should be investigated within a population where study of mathematics is mandatory and among students whose majors do not indicate a mathematics requirement.

4. Although mathematics anxiety was identified among nearly one-third of the surveyed population, and did not appear to significantly influence success or failure in a course of mathematics, further study of the subpopulation of students demonstrating both the highest levels of mathematics anxiety and evidencing poor final course grades might be indicated.

5. The admission by significant numbers of MATH 103 students to mathematics anxiety levels exceeding that reported by the general survey population should be studied further. The existence of mathematic anxiety indicates a lack of confidence with respect to mathematics, a subject these future teachers will be required to teach in elementary school classrooms.

6. Presently, the academic catalog of Salisbury State College fails to list mathematics anxiety as a performance anxiety although other forms of anxiety such as recital anxiety and public speaking anxiety are indicated as areas for which the Counseling Center provides assistance. Since the existence of mathematics anxiety has been identified by this study, and since counselors are aware of the condition known as "mathematics anxiety", effort should be made to publicize in the academic catalog and other appropriate sources, the counseling services that presently exist for students who are math anxious.

7. As an alternative to suggestion #6, ongoing efforts might be instituted to identify math anxious students, perhaps during freshman orientation. Once identified, desensitization efforts such as workshops, or "rap" sessions might be instituted on a collaborative basis with staff from the Counseling Center, Mathematical Sciences Department and Literacy (Mathematics) Task Force participating. Development of a library of math anxiety desensitization materials in the form of books and tapes might be instituted. And finally, if successful with on-campus students, consideration might be given to extending such a program to members of the community at large, (adults, junior and senior high school students) who admit to difficulties in mathematics that they perceive are exacerbated by mathematics anxiety.

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APPENDIX

Appendix A: Research Disclosure Form
(RDF)

RESEARCH DISCLOSURE FORM

The research effort you are about to participate in, represents the data collection and analysis phase of a master's degree thesis on the existence, prevalance and intensity of mathematics anxiety among students at Salisbury State College. The survey will take a few minutes of class time and each participant will be asked questions conjectured to relate to their confidence or anxiety toward mathematics. In attempting to determine correlates of attitudes toward mathematics, the researcher needs to have access to each participant's SAT-MATH score and final grade for this mathematics course. IT MUST BE EMPHASIZED THAT IN NO WAY WILL INDIVIDUAL LINKAGE TO STUDENT NAME OR SOCIAL SECURITY NUMBER BE USED OTHER THAN TO COMPILE GROUP DATA. ALL LINKAGE WILL BE DESTROYED ONCE THE ACCUMULATION OF GROUP DATA HAS BEEN ACHIEVED.

Completion of a master's degree thesis represents the culmination of hundreds of hours of research on the part of a graduate student. To increase the validity of this project, voluntary participation and honest reporting of attitudes are of utmost importance. Be assured that participation and responses will in NO WAY HAVE ANY BEARING ON A STUDENT'S GRADE IN THIS COURSE.

SURVEY FOLLOW-UP INFORMATION

Should participants desire information on the results of this study, they may contact the Mathematical Sciences Department or the researcher through the Learning Center, Caruther's Hall during the spring, 1988 semester. Additionally, any student wanting more information on the nature of mathematics anxiety or its remediation is encouraged to read:

a) "Overcoming Math Anxiety" by Sheila Tobias
b) "Mind over Math" by Warren and Kogelman

or discuss the matter with a member of the staff at the Counseling Center.

Appendix B: Student Consent Form

(SCF)

STUDENT CONSENT FORM

Permission is hereby provided to access my SAT-MATH score, California Achievement Test score, final exam score, and final grade in this course for the purpose of inclusion in group data for a study in mathematics anxiety. I understand that confidentiality will be maintained, in that neither the researcher, nor my instructor will be able to link my name to any of the aforementioned scores and that all linkage to individual social security numbers will be destroyed once group data accumulation has taken place. I further understand that participation in this study will in no way affect my grade in this course of mathematics.

Signed,

____
Student's Signature

____
Social Security Number

Course:________ Section:___________ Date:_______________

Appendix C: Mathematics Anxiety Research Survey

(Student Biographical Data,
Test Anxiety Profile
The Fennema-Sherman Mathematics Anxiety Scale and
The Fennema-Sherman Mathematics Confidence Scale,
Answer Sheet)

_PACKET_NUMBER_ONE

Mathematics Anxiety Research Survey
Salisbury State College
September, 1987

RPH:9/8-9/87

DATA COLLECTION SURVEY

All entries are to be made on the machine-scorable answer sheets provided. Avoid any notations on this survey sheet as they may be reused in other math sections.

Complete the heading of the answer sheet by listing only your social security number, today's date and course and section number in the space provided. Accuracy of this information is essential for data collection, so if you are unsure of your social security number, don't hesitate to ask for assistance; each instructor's copy of the class roster features your correct social security number. Please print legibly.

Complete all questions. Do not leave any blanks. Be sure to provide only one answer per question. Please try to be as accurate as possible in assessing th particular attitude described in the survey.

1. My age is ___ years old.
   a). 16-18
   b). 19-21
   c). 22-25
   d). 26-30
   e). older than 30

2. My sex is:
   a). female
   b). male

3. In the high school curriculum, college preparation math includes introductory algebra, intermediate algebra, geometry, trigonometry, pre-calculus, or advanced placement calculus. The following best describes my hig school courses in college preparation math:
   a). none of the above courses in math were studied in high school
   b). 1 year in any of the above courses was completed
   c). 2 years in any of the above courses were completed
   d). 3 years in any of the above courses were completed
   e). 4 years in any of the above courses were completed

4. It has been ____ since my last class in college preparation mathematics.
   - a). less than 6 months
   - b). 1 year
   - c). 2 years
   - d). 3 years
   - e). more than 3 years

In answering the next questions, indicate which response best describes how yc feel when you take a test other_than_a_test_in_mathematics.

5. When taking a test other_than_a_test_in_mathematics, my breathing is:
   - a). loose
   - b). somewhat loose
   - c). unchanged
   - d). somewhat tight
   - e). tight

6. When taking a test other_than_a_test_in_mathematics, I feel:
   - a). helpless
   - b). somewhat helpless
   - c). ambivalent
   - d). somewhat secure
   - e). secure

7. When taking a test other_than_a_test_in_mathematics, I feel:
   - a). jittery
   - b). somewhat jittery
   - c). ambivalent
   - d). somewhat calm
   - e). calm

8. When taking a test other_than_a_test_in_mathematics, my fingers are:
   - a). relaxed
   - b). somewhat relaxed
   - c). neither relaxed nor stiff
   - d). somewhat stiff
   - e). stiff

9. When taking a test other_than_a_test_in_mathematics, I feel:
   - a). worried
   - b). somewhat worried
   - c). ambivalent
   - d). somewhat carefree
   - e). carefree

10. When taking a test other_than_a_test_in_mathematics, my mind is generall
    - a). working
    - b). somewhat working
    - c). ambivalent
    - d). somewhat carefree
    - e). carefree

11. When taking a test other than a test in mathematics, my thoughts are generally:
    a). jumbled
    b). somewhat jumbled
    c). ambivalent
    d). somewhat easy
    e). easy

12. Before taking a test other than a test in mathematics, my thoughts about my preparedness are generally:
    a). ready
    b). somewhat ready
    c). ambivalent
    d). somewhat unready
    e). unready

13. When actually taking a test other than a test in mathematics, my thoughts at that time are generally:
    a). dangerous
    b). somewhat dangerous
    c). ambivalent
    d). somewhat safe
    e). safe

14. My thoughts when taking a test other than a test in mathematics are generally:
    a). unsure
    b). somewhat unsure
    c). ambivalent
    d). somewhat sure
    e). sure

15. My ideas when taking a test other than a test in mathematics are generally:
    a). clear
    b). somewhat clear
    c). ambivalent
    d). somewhat confused
    e). confused

The following twenty-four questions attempt to assess the range of your attitudes towards mathematics. Indicate as accurately as possible the degree of agreement which most closely matches your reaction to each of the following statements:

16. Math doesn't scare me at all.
    a). strongly disagree
    b). disagree
    c). uncertain
    d). agree
    e). strongly agree

17. It wouldn't bother me at all to take more math courses.
    - a). strongly disagree
    - b). disagree
    - c). uncertain
    - d). agree
    - e). strongly agree

18. I haven't usually worried about being able to solve math problems.
    - a). strongly disagree
    - b). disagree
    - c). uncertain
    - d). agree
    - e). strongly agree

19. I almost never have gotten shook up during a math test.
    - a). strongly disagree
    - b). disagree
    - c). uncertain
    - d). agree
    - e). strongly agree

20. I usually have been at ease during math tests.
    - a). strongly disagree
    - b). disagree
    - c). uncertain
    - d). agree
    - e). strongly agree

21. I usually have been at ease during math classes.
    - a). strongly disagree
    - b). disagree
    - c). uncertain
    - d). agree
    - e). strongly agree

22. Mathematics usually makes me feel uncomfortable and nervous.
    - a). strongly disagree
    - b). disagree
    - c). uncertain
    - d). agree
    - d). strongly agree

23. Mathematics makes me feel uncomfortable, restless, irritable, and impatient.
    - a). strongly disagree
    - b). disagree
    - c). uncertain
    - d). agree
    - e). strongly agree

24. I get a sinking feeling when I think of trying hard math problems.
    - a). strongly disagree
    - b). disagree
    - c). uncertain
    - d). agree
    - e). strongly agree

25. My mind goes blank and I am unable to think clearly when working mathematics.
    - a). strongly disagree
    - b). disagree
    - c). uncertain
    - d). agree
    - e). strongly agree

26. A math test would scare me.
    - a). strongly disagree
    - b). disagree
    - c). uncertain
    - d). agree
    - e). strongly agree

27. Mathematics makes me feel uneasy and confused.
    - a). strongly disagree
    - b). disagree
    - c). uncertain
    - d). agree
    - e). strongly agree

28. Generally I have felt secure about attempting mathematics.
    - a). strongly disagree
    - b). disagree
    - c). uncertain
    - d). agree
    - e). strongly agree

29. I am sure I could do advanced work in mathematics.
    - a). strongly disagree
    - b). disagree
    - c). uncertain
    - d). agree
    - e). strongly agree

30. I am sure I can learn mathematics.
    - a). strongly disagree
    - b). disagree
    - c). uncertain
    - d). agree
    - e). strongly agree

31. I think I could handle more difficult mathematics.
    a). strongly disagree
    b). disagree
    c). uncertain
    d). agree
    e). strongly agree

32. I can get good grades in mathematics.
    a). strongly disagree
    b). disagree
    c). uncertain
    d). agree
    e). strongly agree

33. I have a lot of self-confidence when it comes to math.
    a). strongly disagree
    b). disagree
    c). uncertain
    d). agree
    e). strongly agree

34. I'm no good in math.
    a). strongly disagree
    b). disagree
    c). uncertain
    d). agree
    e). strongly agree

35. I don't think I could do advanced mathematics.
    a). strongly disagree
    b). disagree
    c). uncertain
    d). agree
    e). strongly agree

36. I'm not the type to do well in math.
    a). strongly disagree
    b). disagree
    c). uncertain
    d). agree
    e). strongly agree

37. For some reason, even though I study, math seems unusually hard for me.
    a). strongly disagree
    b). disagree
    c). uncertain
    d). agree
    e). strongly agree

38. Most subjects I can handle O.K., but I have a knack for flubbing up math.
    a). strongly disagree
    b). disagree
    c). uncertain
    d). agree
    e). strongly agree

39. Math has been my worst subject.
    a). strongly disagree
    b). disagree
    c). uncertain
    d). agree
    e). strongly agree

Please look over your answer sheet to be certain:

- your correct social security number is entered in the proper place on both the answer key and student consent form,
- the correct course and section numbers are included,
- only one response per line has been entered.

Once assured of completeness of the survey, turn in all materials and await distribution of Packet Number Two.

SCANTRON FORM NO. 22000

FEED THIS DIRECTION

⊂0⊃	⊂1⊃	⊂2⊃	⊂3⊃	⊂4⊃	⊂5⊃	⊂6⊃	⊂7⊃	⊂8⊃	⊂9⊃	WRITE I.D. NUMBER HERE
[redacted]										[redacted]
⊂0⊃	⊂1⊃	⊂2⊃	⊂3⊃	⊂4⊃	⊂5⊃	⊂6⊃	⊂7⊃	⊂8⊃	⊂9⊃	
[redacted]										[redacted]
⊂0⊃	⊂1⊃	⊂2⊃	⊂3⊃	⊂4⊃	⊂5⊃	⊂6⊃	⊂7⊃	⊂8⊃	⊂9⊃	
[redacted]							⊂7⊃	⊂8⊃	⊂9⊃	[redacted]
⊂0⊃	⊂1⊃	⊂2⊃	⊂3⊃	⊂4⊃	⊂5⊃	⊂6⊃	⊂7⊃	⊂8⊃	⊂9⊃	MARK I.D. NUMBER HERE
⊂0⊃	⊂1⊃	⊂2⊃	[redacted]				⊂7⊃	⊂8⊃	⊂9⊃	[redacted]
⊂0⊃	⊂1⊃	⊂2⊃	⊂3⊃	⊂4⊃	⊂5⊃	⊂6⊃	⊂7⊃	⊂8⊃	⊂9⊃	
⊂0⊃	⊂1⊃	⊂2⊃	⊂3⊃	⊂4⊃	⊂5⊃	⊂6⊃	⊂7⊃	⊂8⊃	⊂9⊃	

EXAMPLE:

⊂0⊃	⊂1⊃	⊂2⊃	⊂3⊃	⊂4⊃	⊂5⊃	⊂6⊃	●	⊂8⊃	⊂9⊃	WRITE I.D. NUMBER HERE	7
[redacted]											
⊂0⊃	⊂1⊃	⊂2⊃	⊂3⊃	●	⊂5⊃	⊂6⊃	⊂7⊃	⊂8⊃	⊂9⊃		4
⊂0⊃	⊂1⊃	⊂2⊃	⊂3⊃	⊂4⊃	⊂5⊃	●	⊂7⊃	⊂8⊃	⊂9⊃		6
⊂0⊃	⊂1⊃	⊂2⊃	⊂3⊃	⊂4⊃	●	⊂6⊃	⊂7⊃	⊂8⊃	⊂9⊃	MARK I.D. NUMBER HERE	5
[redacted]											
⊂0⊃	⊂1⊃	●	⊂3⊃	⊂4⊃	⊂5⊃	⊂6⊃	⊂7⊃	⊂8⊃	⊂9⊃		2
[redacted]											

PART 1

CODE I.D. NUMBER AT LEFT BY FILLING IN THE APPROPRIATE BOXES ACCORDING TO THE EXAMPLE.

	NKS				C1 KEY		SP	NE			C2 KEY
1	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃	51	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃
2	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃	52	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃
3	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃	53	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃
4	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃	54	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃
5	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃	55	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃
6	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃	56	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃
7	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃	57	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃
8	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃	58	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃
9	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃	59	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃
10	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃	60	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃
11	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃	61	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃
12	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃	62	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃
13	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃	63	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃
14	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃	64	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃
15	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃	65	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃
16	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃	66	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃
17	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃	67	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃
18	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃	68	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃
19	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃	69	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃
20	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃	70	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃
21	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃	71	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃
22	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃	72	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃
23	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃	73	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃
24	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃	74	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃
25	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃	75	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃
26	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃	76	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃
27	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃	77	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃
28	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃	78	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃
29	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃	79	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃
30	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃	80	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃
31	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃	81	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃
32	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃	82	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃
33	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃	83	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃
34	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃	84	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃
35	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃	85	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃
36	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃	86	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃
37	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃	87	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃
38	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃	88	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃
39	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃	89	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃
40	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃	90	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃
41	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃	91	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃
42	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃	92	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃
43	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃	93	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃
44	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃	94	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃
45	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃	95	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃
46	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃	96	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃
47	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃	97	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃
48	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃	98	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃
49	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃	99	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃
50	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃	100	⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃
	(T)	(F)					(T)	(F)			

IMPORTANT

USE NO. 2 PENCIL ONLY

- MAKE ***DARK*** MARKS
- EXAMPLE: ⊂A⊃ ⊂B⊃ ● ⊂D⊃ ⊂E⊃
- ERASE ***COMPLETELY*** TO CHANGE

NAME ____________________

SUBJECT ____________________

HOUR __________ DATE __________

KEY MARKING INSTRUCTIONS

This form is used for:

a) Program Key
b) Test Answer Sheet

When used as Program Key, you can control the results depending on which Key Boxes are marked.

	COLUMN 1					COLUMN 2					
	NKS				C1 KEY	SP	NE			C2 KEY	KEY BOXES
	1⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃	51⊂A⊃	⊂B⊃	⊂C⊃	⊂D⊃	⊂E⊃	ANSWER BOXES

Marking a Key Box or Combination of Key Boxes produces the following scoring and error marking results:

NKS	No score printed on Key
C1 KEY	Prints score and error marks for column 1.
C1 KEY NE	Prints score for column 1 with no error marks.
C2 KEY	Prints score and error marks for column 2.
C2 KEY NE	Prints score for column 2 with no error marks.
C1 KEY C2 KEY	Prints total score and error marks for columns 1 and 2.
C1 KEY C2 KEY NE	Prints total score for columns 1 and 2 with no error marks.
C1 KEY C2 KEY SP	Prints separate scores for columns 1 and 2 with no error marks.

After marking the appropriate Key Boxes, mark correct answers on your program key.

Appendix D: Mathematical Sciences Departmental Diagnostic Test (MSDDT) Answer Sheet

PACKET NUMBER TWO

Mathematics Departmental Diagnostic Test
Salisbury State College
September, 1987

The Mathematical Sciences Departmental Diagnostic Test

1. $\frac{4}{5} = ?$

a) .8% b) 8% c) 12.5% d) 1.25% e) none of these

2. If $4x - 3 = 5x + 7$, then $x = ?$

a) -10 b) 4 c) -4 d) 10 e) none of these

3. If $\frac{3}{7x} = 2$, then $x = ?$

a) $\frac{6}{7}$ b) $\frac{7}{6}$ c) $\frac{14}{3}$ d) $\frac{3}{14}$ e) none of these

4. If $4x - 3 = 2(3x - 4)$, then $x = ?$

a) $\frac{-11}{2}$ b) $\frac{5}{2}$ c) $\frac{1}{2}$ d) $\frac{-7}{2}$ e) none of these

5. If $x = -1$, what is the value of $3x^3 - 2x^2 + x - 1$?

a) -7 b) -3 c) -1 d) 3 e) none of these

6. If $3x - y = 9$ and if $2x + y = 11$, then $x = ?$

a) 0 b) 5 c) 3 d) 4 e) none of these

7. If $v = \frac{r + s}{t}$, then $s = ?$

a) $vt \underset{t}{-} r$ b) $\frac{r + v}{r}$ c) $\frac{r + v}{t}$ d) $(v - r)t$ e) none of these

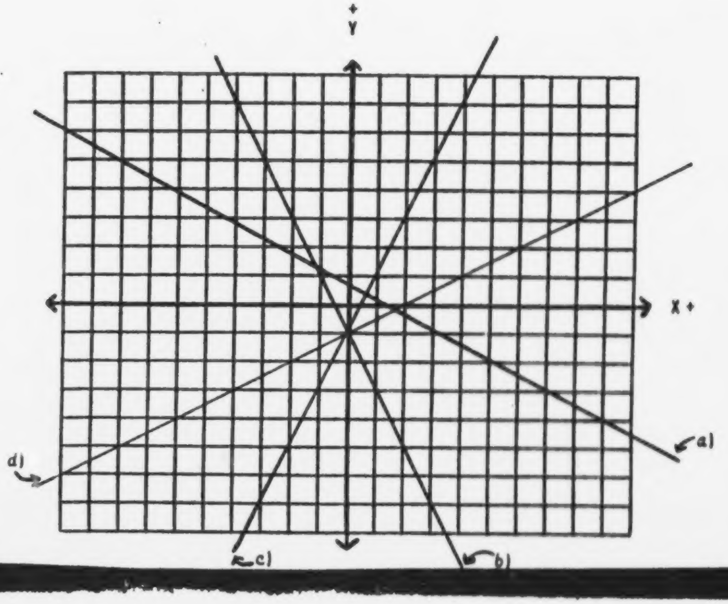
8. $(2x + 3)(3x - 2) = ?$

a) $11x - 6$ b) $5x + 1$ c) $6x^2 + 9x - 6$ d) $6x^2 + 5x - 6$ e) none of these

9. $(2x - 3)^2 = ?$

a) $4x^2 - 6x - 9$ b) $4x^2 - 12x + 9$ c) $4x - 6$ d) $4x^2 - 6x + 9$ e) none of these

10. Which of the following graphs represents the relation $y = 2x - 1$?



SSC DEPARTMENT OF MATHEMATICAL SCIENCES

Screening and Self-Assessment Answer Sheet

Last Name First Name

Social Security Number

Course Number Section Number

Instructor

	(A)	(B)	(C)	(D)	(E)
1.	A	B	C	D	E
2.	A	B	C	D	E
3	A	B	C	D	E
4.	A	B	C	D	E
5.	A	B	C	D	E
6.	A	B	C	D	E
7.	A	B	C	D	E
8.	A	B	C	D	E
9.	A	B	C	D	E
10.	A	B	C	D	E

What mathematics classes did you take during each of the following years?

9th grade ____________________

10th grade ____________________

11th grade ____________________

12th grade ____________________

PLEASE DO NOT MARK ON THE TEST; use a sheet of scratch paper. The symbol "*" will be used to indicate multiplication. For example, $3 * 4 = 12$ is read "3 times 4 equals 12".

MARK ONLY ONE ANSWER FOR EACH QUESTION

If you do not know the answer to a question, do not guess - just leave the answer blank. As an example of marking, if the answer to a question is "D", mark your sheet as follows:

(A)	(B)	(C)	(D)	(E)
A	B	C	■	E

Appendix E: Instructions for Administration of Research Items

From: Mrs. Rosemary Heher, Instructor, Developmental Studies (Mathematics)
To: Instructors of all MATH 103 and 150 sections for fall, 1987
Date: August 20, 1987
Subject: Data collection for master's thesis project assessing student mathematics anxiety.

On September 8 & 9, 1987, research will be conducted in all sections of MATH 103 and 150 for the purpose of compiling data on the existence, prevalence and intensity of mathematics anxiety among a sample population of students at Salisbury State College.

In order to standardize the testing procedure, an abstract of the project is provided for your perusal. You are encouraged to familizarize yourself with the research effort in the event student questions arise.

Please read aloud the "Research Disclosure Form" which is required by the Committee on Human Volunteers. "Student Consent Forms" should then be distributed, completed and collected. Designated envelopes will be provided in each section for storage of these permission slips.

Actual testing will take place in the form of two packets: Packet I is untimed and consists of an op-scan answer sheet and a consolidation of the Test Anxiety Profile and the Fennema-Sherman Mathematics Anxiety and Confidence Scales as well as biographical data. All entries are to be made on the computer answer sheet provided. Packet I consists of 39 multiple choice items and should take no more than ten minutes to complete. Please read the directions aloud, answering any questions which arise. When students have completed all items in Packet I, collect the materials in such a manner that all the op-scan answer sheets are placed in a designated envelope while test questions are collected and bundled together.

Packet II consists of timed material. Packet II is the Math Departmental Diagnostic Test which is usually administered in most introductory math courses at this college. For purposes of this study, the test will be administered this semester to Math 103 students. Administer this test as you have in the past. Arrangements have been made with the Math Department to provide this researcher with the results of the diagnostic test once student placement based on test scores has occurred. Please be sure in collecting the diagnostic answer sheet, that all student social security numbers are entered.

Once collection of survey tests (Packet I & II) and accompanying answer sheets have been completed, the Committee on Human Volunteers has asked that each test respondent be provided with a "Survey Follow-Up Information" form. Return all materials to the Math Office at the end of each class session.

Thank you in advance for your assistance in helping me compile data for my master's thesis. I will provide you with all testing materials prior to the day of testing. If you have any questions concerning this project, or your participation in it, please feel free to contact me on campus at extension 6391 or at home at 742-4925.

Appendix F: Approval-Human Volunteers Committee

Statement of Approval
Committee on Human Volunteers
Salisbury State College

Date May 26, 1987

MEMORANDUM TO: Rosemary Heher

FROM : Chairman, Committee on Human Volunteers

SUBJECT : The Use of Fennema-Sherman Mathematics Anxiety and Confidence Scales as Predictors of Success . . . .

Title of Study

Grant Application No.

S. S. C.
Sponsoring Agency

Rosemary Heher
Principal Investigator or Program Director

The Committee on Human Volunteers has considered the above application and, on the basis of available evidence, records its opinion as follows:

(1) The rights and welfare of individual volunteers are adequately protected.

(2) The methods to secure informed consent are fully appropriate and adequately safeguard the rights of the subjects (in the case of minors, consent is obtained from parents or guardians).

(3) The investigators are responsible individuals, competent to handle any risks which may be involved, and the potential medical benefits of the investigation fully justify these studies.

(4) The investigators assume the responsibility of notifying the Committee on Human Volunteers if any changes should develop in the methodology or the protocol of the research project involving a risk to the individual volunteers.

Chairman

8/86